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THE

AMERICAN

JOURNAL OF SCIENCE.

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THIRD SERIES.

VOL. XL.—[WHOLE NUMBER, CXL.]

No. 238.—OCTOBER, 1890.

NEW HAVEN, CONN.: J. D. & E. S. DANA.
1890.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 371 STATE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

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THE

AMERICAN JOURNAL OF SCIENCE

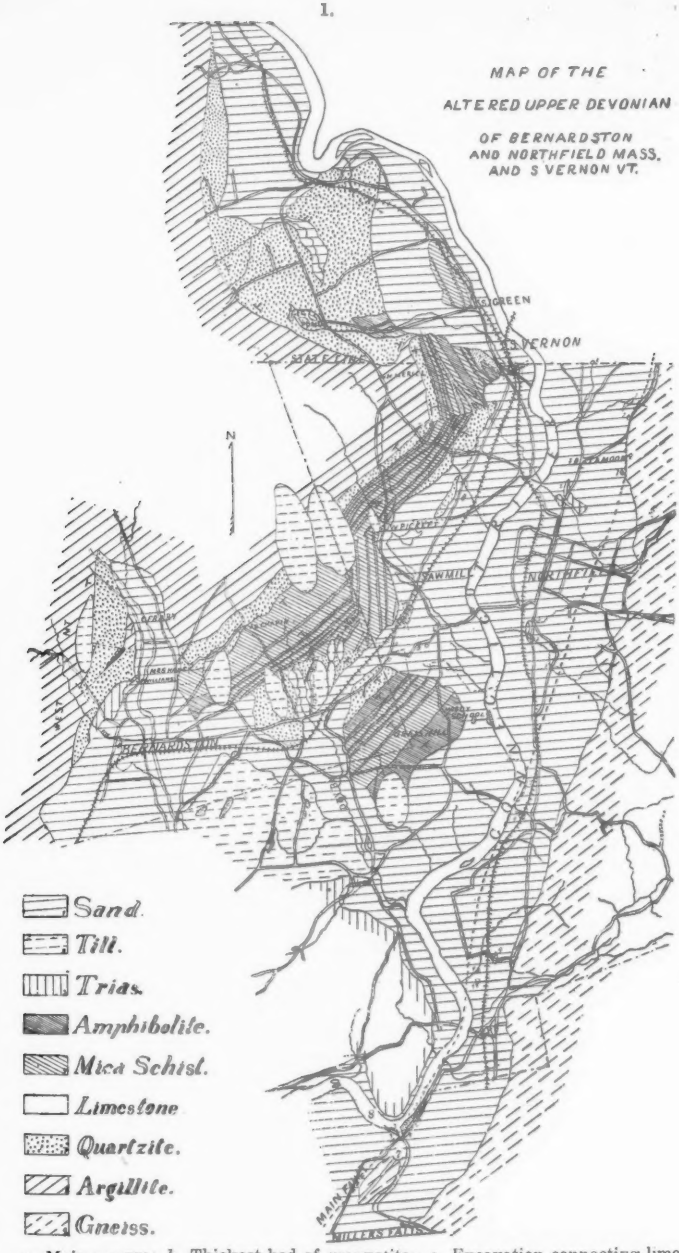
[THIRD SERIES.]

ART. XXXV.—*A description of the "Bernardston Series" of Metamorphic Upper Devonian Rocks;* by BEN K. EMERSON.*

1. *Description of the Region.*—The terrace sands of the Connecticut river are narrow upon its western side where the river crosses the State line, and they continue with little increase of width for four miles southwesterly, and then, as they enter Bernardston, their boundary upon the older rocks turns abruptly west, and runs for seven miles a little south of west, past the village of Bernardston, and along the north line of Greenfield. Bernardston village stands just in the middle of this line, and at the mouth of a narrow valley, up which a lobe of the alluvial sands reaches northwardly for nearly two miles. On the west, this valley is bounded by the high ridge of West Mountain, made up of the contorted argillite which stretches in a narrow band far north, across Vermont, and disappears below the river

* The introductory part of this paper, giving a history of previous investigations in the region, is here omitted. The publications mentioned in it, which are of chief interest in this connection, are: Prof. Edward Hitchcock's Report on the Geology of Massachusetts, 1833, and 2d ed. 1835, the latter mentioning the discovery of Crinoids and giving figures; the Report on the Geology of Vermont, by E. and C. H. Hitchcock, i, 447 and ii, 598, 1861; the two papers of J. D. Dana in this Journal, III, vi. 339, 1873, and xiv, 379, 1877; a paper by C. H. Hitchcock in this Journal, xiii, 313, 1877; also observations by C. H. Hitchcock in the Geology of New Hampshire, ii, 428, 1877; a short paper by R. P. Whitfield on the fossils of Bernardston, based chiefly on specimens of new forms discovered by Prof. Emerson, published in this Journal, XXV, 368, 1883.

The investigation by Prof. Dana had in view the chronological canon with regard to crystalline rocks—that kind of rock was a safe criterion of geological age—and that, under it, "staurolite crystals were as good as fossils" for the purpose. The metamorphic Taconic region of western New England, and the



a. Main quarry; *b.* Thickest bed of magnetite; *c.* Excavation connecting limestone with quartzite; *d.* Excavation exposing fault of mica schist against limestone; *e.* Same as *d*; *f.* Contact of quartzite on argillite.

sands on the north line of Greenfield, appearing again only in the limited outcrop just west of the village of Whately, fifteen miles farther south, and in one newly discovered at the mouth of Mill River. Everywhere the slope of the West Mountain shows only the black argillite, except in a single band back of the house of Mr. Williams, a mile north of the village, where, apparently resting upon the argillite, occurs the fossiliferous series. The section has a width going up the hillside on the line of dip, of only 1050^{m}, and is nowhere exposed, on the strike, more than a tenth of this distance. The outcrops of the argillite to the north and south show that there can be only a very limited amount of the newer series preserved upon the hillside, while the heavy accumulation of till generally prevents one's seeing its limits or its contact upon the rock below. It approaches the argillite quite closely upon the west and in the line of strike can not be more than 3000^{m} long. Over against the West Mountain on the east, across the narrow valley of Fall River, rises a range of hills bounded on the south and east by the terrace sands, which is composed of a similar series of rocks in similar succession. The principal difference between the two is that on the east a dark hornblende rock, often massive, takes its place in the series while the limestone and magnetite bed of the typical section are wanting, and all the other members are somewhat more metamorphosed. Staurolite occurs in the schists, feldspar crystals and biotite in the quartzites, and they are thrown into complex folds and greatly faulted. They lie in fact along the center of the great synclinal of the Connecticut valley which is an area of maximum disturbance of the rocks quite across the State. These discrepancies become less important when it is noted that hornblende exists in considerable quantity directly above the Williams farm limestone, and the second bed of the same limestone in South Vernon is encased in hornblende schist. Across the river in Northfield the white

Bernardston of central, being known to afford fossils, the former of Lower Silurian age and the latter of Lower or Upper Helderberg, these were selected as regions for ascertaining what kinds of crystalline rocks might be of these different periods for comparison with Archæan crystalline rocks. (The Lower Silurian age of the Taconic system was hardly questioned in 1873 by any one.) Prof. Dana's papers on the Bernardston region describe among these rocks, besides the limestone and quartzyte, garnetiferous mica schist, staurolite slate, gneiss, and various hornblendic rocks, including quartz-syenite.

Prof. Emerson has given the region a thorough investigation, in which he has removed the doubts as to the relations of the beds, made out, as far as possible, the system of faults and flexures, studied the rocks as to their kinds and transitions, and determined the age of the series to be Upper Devonian. The paper will be accepted in America, and should be elsewhere, as putting the facts beyond doubt that gneiss, dioryte, granite, and the other crystalline rocks described are not always of Archæan or pre-Cambrian make; that dioryte and granite are not always of igneous origin; and these conclusions are made sure on the well-established criterion of age, that is, fossils—Crinoids, Corals, Brachiopods. J. D. D.

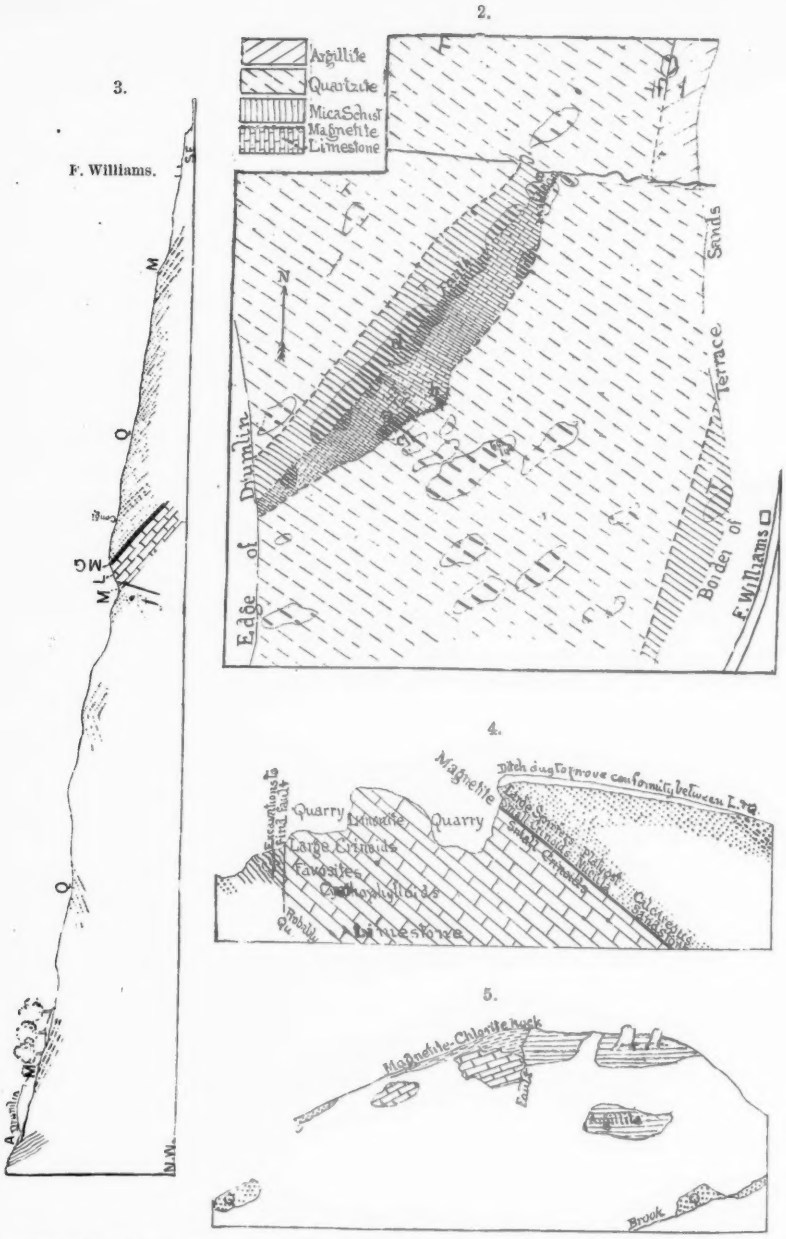


Fig. 2. Map of Devonian rocks, Williams Farm; 3. Section of same; 4. Section at limestone quarry, including *a* to *c* of map, fig. 2; 5. corresponding to *e*, of fig. 2,—the brook, the course of a fault, faulting the quartzyte.

saccharoidal quartzite extends to the base of the Northfield Mountain and is there bounded by a north-south fault, while only a single outcrop of schist is exposed.

2. *The relation of the Bernardston series to the Argillite.*—It was originally assumed by President Hitchcock that the argillite and the schists of this series were conformable. Professor J. D. Dana,* finding the argillite about a half mile west of the limestone to have a much higher dip, decided that they were unconformable to, and much older than, the upper series, and this conclusion was accepted by Prof. C. H. Hitchcock.† I have, in tracing the distribution of the quartzite, given five localities where the boundary of the quartzite and argillite is well exposed, and I could increase the number, and in each case there is apparent conformity and a uniform passage from the common argillite, into argillite with minute garnets and minute biotite spangles, fine-grained black quartzite graduating into coarser quartzite and conglomerate. The argillite is extremely corrugated and often cleaved, and observations of dip a rod from the contact are of no value as settling a question like this.

3. *The Williams Farm Section.*—See maps 1 and 2 and sections, figs. 3, 4, 5. The long band of the rocks of the Bernardston series along the lower slope of the West Mountain has been brought into its present position by extensive dislocations and is plainly cut by two transverse faults which run approximately with the brook gorge north of the limestone and with the larger gorge of Fox brook half a mile south. The area between containing the fossiliferous limestone is the one here described.

Passing up the hillside, back of Mr. Williams's barn, the first bed and the upper one on the section (fig. 3) is a dark muscovite schist, which is exposed in a single small quarry and separated by a depression which runs with the strike, and which I have supposed in the section to be occupied by the same schists and to have been formed by their erosion. The outcrops are almost continuous across the quartzite and limestone which follow, to the second outcrop of schist, where a similar depression separates the latter from the second band of quartzite, which I have in like manner supposed to be occupied by this schist. The thicknesses given in the section are, with this explanation, the result of careful measurement; and the elevations taken with two closely agreeing aneroids, and referred to the sea level by means of the height of the railroad station at Bernardston, corrected so as to agree with Gen. Ellis's survey of the Connecticut River.

* This Journal, III, vi, 343.

† Geol. N. H., ii, 433, 1887.

Section of the Williams' Farm Rocks.

1. Garnetiferous mica schist	22·5	m.
2. Micaceous quartzite and conglomerate	135·	"
3. Magnetite, maximum	1·	"
4. Limestone	6·	"
Fault		
1. Mica schist	35·	"
2. Quartzite and conglomerate if conformable with the mica schist	200·	"

The beds below the fault are a repetition of those above.

a. The Argillite (fig. 3, A, west end).—Beginning nearly a mile northwest of the Williams house, and just north of the point where the road over West Mountain bends sharply west, a long ridge of the typical elaborately contorted argillite extends northerly. Going east a drumlin conceals its contact with the newer rock, and I have represented beneath the till a comformable contact of the argillite and the quartzite as I have found it everywhere in the region. (See fig. 2.)

b. The western outcrop of the mica schist.—Where the series outcrops for the first time after crossing the drumlin, a small area of the mica schist of this series has recently come to my notice. It is a garnetiferous mica schist, like the more eastern outcrops, and it lies plainly in a small synclinal of the quartzite. It lies ten rods south of the western of a row of great chestnuts which crown the hill.

c. The western exposures of the quartzite.—The discovery of the schist just described makes plain the structure of these quartzite outcrops with their western dip. As they lie in a small synclinal the quartzite makes a corresponding anticlinal before reaching the outcrop of the mica schist. The rock is dark gray quartzite, at times conglomeratic, weathering very rough, with strike and dip very irregular and uncertain, with many slight slips and crushings, indeed, often completely brecciated and recemented with limpid quartz. Locally it passes into a black siliceous slate by the microscopical development of biotite and the accumulations of coaly matter. A few scales of the former mineral can be seen with the lens. Going up the hillside from the limestone along the line of dip, two small ledges of the rock appear, as may be seen from the section, widely separated from each other, and from the rocks above and below.

It is not difficult to find, among the less crushed portions of each ledge, pieces which agree exactly with the quartzite above the limestone, especially that which outcrops a few meters above the latter, and its peculiar appearance is largely due to crushing and infiltration of quartz. The same result is reached

by examining the quartzite ledges along the strike north and south from this point and comparing them with the "upper quartzite."

d. The mica schist west of the limestone.—This rock is a dark, even-bedded, muscovite schist, so fine grained as to be almost indistinguishable from the even-bedded varieties of the argillite below, with its glistening surface pitted here and there by minute hollows from which small red dodecahedral garnets have fallen out. It is abundantly marked by small bodies, which appear much like minute altered chiastolites just visible to the eye. The minute chiastolite-like forms prove to be made up externally of bands of quite large muscovite plates, each normal to the long sides of very impure biotite crystals, the latter placed transversely to the bedding of the rock. Under the microscope the rock shows a fine, scaly, colorless ground mass, dotted abundantly with coaly matter, and made up mostly of muscovite plates with some apolar matter, apparently opal. The constituents are a little larger than in the argillite, and the coaly matter less abundant. No kaolin could be detected. The much-fissured clear garnets are surrounded by a black band from the repulsion of the coaly matter, within which a broad decomposition band of chlorite in twisted scales appears which often extends nearly to the center. They contain large grains of quartz irregularly arranged. The biotite incloses garnet, and the muscovite forms caps around the garnet, and arranges itself symmetrically to the biotite, so the order of crystallization is very generally garnet, biotite, muscovite. The large amount of impurity in the biotite indicates that when it formed the rock was more carbonaceous than at present. Leucoxene occurs in yellowish white grains less abundantly than in the argillite

e. Fault between the schist and limestone, d, fig. 2.—The bed last described dips under the limestone apparently, with the strike N. 70° E. and dip 25° to 35° E. But just opposite and northwest of the largest excavation in the limestone, and under a small apple tree where the schist seemed certainly to go under the limestone, and where Prof. Dana and the writer dug away and followed it for six inches under the limestone, later I had excavations made, having doubted the reality of the apparent conformable superposition, because the bed of limestone rested on the schist with abrupt transition and total want of continuity. I found the two rocks to be faulted against each other, the wall of the limestone bending under for a few inches and then going down vertically, and the schists, so flat in the exposures below, were here crumpled up sharply and ground into shapeless masses against the limestone. I followed the fault down more than a meter without finding the bottom of

the limestone, but found mingled in the crunched schist fragments of the chloritic rock, which lies below the limestone and is exposed in the bluff to the north. At a later date I had further excavation made, uncovering the northern bluff where also the mica schist approached the limestone at its northern end, and I exposed here a zigzag fault line between the schist on the west and the black, magnetite-pyrite-chlorite-limestone, and below this with the white limestone itself, *e* on map, fig. 2. The fault plane is nearly vertical. The relation of the beds at this point are made plain by fig. 5. This latter excavation was made by direction of the United States Geological Survey.

f. The Limestone.—The limestone which forms the center of interest of the section, is exposed in many old pits, extending from the bluff overlooking the brook, to the largest opening overhung by birches, where the rock is most fossiliferous; and the line of outcrops is continued, by more scattered openings, farther southwest. It extends in all about 125 m. from northeast to southwest, that is along the line of strike. It is for the most part a coarsely crystalline, saccharoidal limestone, at times so coarse that cleavage pieces of calcite 8 centimeters across can be obtained from it. Below it is in thick beds with stratification mostly obliterated, while the upper portion, for about 2 meters, is thin-bedded, finer grained and micaceous. The rock contains some pyrite, which with the more abundant deposit of the same in the bottom of the quartzite, has been the source of the great amount of porous limonite, which fills broad veins and great cavernous spaces in the limestone. Its modern formation is attested by the rootlets changed into limonite enclosed in it.

It makes a strange impression to turn over a mass of coarsely crystalline limestone, and find the weathered surface covered with Crinoid stems or Corals. In masses showing no trace of fossils, these are brought out equally well in thin sections; and I have even observed a fragment of the shell of a Terebratula, preserving the punctate structure, the pores agreeing closely in position and measurement with those of modern genera.

In the section fig. 4 all the fossils known are assigned to their proper horizon so far as known to me. I would especially note the fact, to which my attention was first called by Professor J. M. Clarke, that the line of division between the two paleontological horizons represented falls well down in the limestone, and that the upper meter of the latter is thin bedded and wants the forms found below, while it carries the peculiar annulate crinoid stems found also very abundantly in the quartzite above.

The shaly limestone is in places much fissured and cemented at times with veins 5–10^{mm} wide of a completely granitoid

mixture of quartz and muscovite, the plates of the latter extending quite across the vein, while the cemented rock still shows abundant crinoid stems. The limestone contains:

$CaCO_3$ 98·38 Fe_2O_3 0·62 SiO_2 1·00

g. The Magnetite bed.—In the largest opening under the main group of birches the limestone for the upper three inches is impregnated with magnetite and the quartzite above this is fossiliferous. Following this boundary north 15 meters the ferruginous horizon swells out to a thickness of one meter and is here represented by a bed of porous limonite. At the same distance farther north it is a bed of fine-grained magnetite, often pyritous, and in one place garnetiferous, and nearly a meter thick. It is of limited extent, but furnishes blocks of ore not to be distinguished from Laurentian magnetites. Analysis indicates phosphorus as well as sulphur.

A little farther north where the base of the quartzite is exposed over the thickest magnetite, it is a dark gray quartz schist, abounding in pyrite, much crushed, and the fissures covered with small fresh rosettes of gypsum crystals, and with drusy crusts of a mineral of earlier formation, now much decomposed, which seems to be prehnite; but from the small size (5^{mm}) of the crystals, and their altered state, they could not be certainly determined. The form of the crystals is peculiar, as if each were made up of half a dozen long square prisms bounded above by a dome and placed side by side, producing a form like a section of a thick saw blade.

At the point where the magnetite is thickest—one meter—I exposed by digging, its contact with the limestone below and with the quartzite above, and found it to pass gradually into the white limestone below and to graduate above into a thick layer (20^{mm}) of a compact grayish black rock, rusting red and glistening under the lens with fine biotite. Under the microscope it proved to be a granular limestone with regularly disseminated biotite scales, of so strong absorption that basal sections are opaque except in the thinnest portions, and then greenish brown. It is thus unlike all the micas of the region and perhaps is phlogopite. The mica is abundantly and regularly spread through the mass, exactly as in a whetstone schist. A single crystal of hornblende, little coaly matter and rust, the fragment of a punctate Brachiopod and the arm-piece of a Crinoid occur in the slide. This rock graduates into the black pyritous quartzite above; all the beds are so entirely continuous, and undisturbed, that it is impossible to think of faulting, or any irregularity at the junction, any more than at the opening farther south under the birches, where the junction is equally undisturbed. The paleontological evidence

reinforces the stratigraphical for the continuity of the limestone and the quartzite. At its northern end, overhanging the brook in the most northerly digging, the magnetite layer is a black, magnetite-pyrite-chlorite rock. Fig. 4, and *e*, fig 2. This rock which caps the limestone contains amphibole, biotite, chlorite and little pyrite, magnetite and hematite, and an amorphous mineral resembling serpentine. The biotite is very dark colored in basal sections and in places changing into chlorite and passing at the edges into the serpentine-like mineral. In the larger part of the section it has a fibrous structure the fibers grouped into large elongate patches, at times radiate and the whole resembling a fine hornblende schist. It is of oil-green color, shows only in patches a trace of dichroism, and with polarized light there is a faint predominance of extinction at about 3° from the long axis of the fibrous groups, which proceeds from the whole group; and this is overlaid as it were by the aggregate polarization of the serpentine-like mineral in fine scales and needles. An analysis made for me by Mr. G. H. Corey, of the class of '88 in Amherst College, gave:

SiO_2 42·56, Fe_2O_3 44·25, CaO 13·11 = 99·92.

The absence of magnesia from this analysis is puzzling, as the product of decomposition of the hornblende resembles serpentine strongly. It is possible that a highly ferruginous amphibole has developed in the magnetite-calcite bed and this has changed into a ferruginous mineral allied to chloropal.

h. The eastern bed of Quartzite.—Under the birches, as represented in the section, fig. 4, one meter of a thin, evenly laminated, light gray quartz-schist caps the limestone, and is very rusty especially at the base, and porous from the amount of pyrite and calcite that has been removed. Two-thirds the way up a layer of about 10^{cm} thickness is crowded with flattened and distorted casts of Brachiopoda and of annulate Crinoid stems; a large Spirifer, with septa like *S. disjuncta*, is very abundant. Traces also of *Rhynchonella* and *Orthis* are common, of *Nucula* and *Platyostoma* rare, and the ringed Crinoid stems again very common. The material I have been able to obtain has been submitted to Mr. J. P. Whitfield and discussed by him in this Journal.* The fossiliferous bed is of very limited lateral extent, and I could trace it only about three meters.

The next outcrops, 15 m. east, and about 2 m. above the bed just described, is a hard gray quartzose conglomerate, with white flattened quartz pebbles, 10–25^{mm} across. Under the microscope, the rock is seen to be made up of angular grains, with large cavities filled with water, containing spherical

* Vol. xxv, page 368, 1883.

highly refringent globules with moving bubbles. It carries also carbonaceous matter in globules, magnetite, pyrite, a little hornblende and muscovite, which latter forms the partings between the pebbles. It resembles much more closely the quartzite described above, p. 268, *c*, than it does the rest of the quartzite above and below it. The quartzite continues very compact, vitreous and unevenly bedded for 20 m. down the hill, and in its upper portion carries garnets. It then becomes thin-laminated, separating into layers about 30^{mm} thick, which are, in fresh cross section, white to bluish vitreous quartz, and the surface of the plates is coated with muscovite. It is finely jointed, and the surfaces of the broad plates are somewhat warped, giving varying dips. Higher up it is cut by great veins of quartz, and in the last outcrop before reaching the upper schist it is again a compact quartzose conglomerate. The strike of the rock averages N. 60° E., but varies between N. 25° E. and N. 70° E. The dip is generally 30°–35° E. but varies from 25° to 50°. At the large quarry a single surface three meters square gave 25° above and 42° below.

i. On the conformity of the Limestone and the overlying Quartzite.—Since the limestone, the magnetite band and the ferruginous quartzites immediately overlying the latter are visibly conformable, and all contain the same fossils as several times indicated above, there remained in this direction only one question unanswered, namely, what was the relation of the series exposed in the large quarry at the birches and mentioned in the last paragraph, to the quartz conglomerate with flattened pebbles exposed 15 meters to the east and thus to the whole mass of the quartzite. The latter seems much more metamorphosed and it might be urged that a fault intervened between the two. On the other hand the conglomerate is typical of that extending from this point northeast to South Vernon and thence north nearly to Brattleboro, and the exact proof of their conformity would greatly enlarge the value of the limestone for fixing the age of the rocks. For this reason I had pits dug three meters apart from the top of the rusty quartzite to the nearest outcrop of the conglomerate to the east, and found the quartzite apparently continuous and no indication of any fault between the two.

As this did not wholly settle the question I had a trench dug exposing the ledge the whole distance from the fossiliferous quartzite to the conglomerate. It exposed a continuous surface of the black shaly quartzite for forty-seven meters and conglomerate for three meters, with strike N. 50° E., dip 40° E., and each layer dipped conformably beneath the succeeding one and the possibility of any fault was wholly excluded. See section 1. Fig. 3 and *c*, fig. 2.

j. The upper outcrop of the Mica schist.—This outcrop occurs 50 meters distant from the uppermost outcrop of the quartzite, in a single small ridge 40 meters long and 20 meters wide, with strike N. 48° E. (41° to 51°) and dip 30° E. (25° to 34°). Figure 3, east end.

It is a dark gray fissile muscovite schist, splitting into thin slabs. Its surfaces are pimpled with small garnets and biotite crystals, or pitted by the cavities left when the crystals remained in the adjoining slab of schist; and it carries abundantly small dark brown biotite crystals, long prisms with rounded angles $1{\cdot}5 \times 2{\cdot}5^{mm}$, and placed generally with their broad cleavage face at a large angle to the bedding plane of the rock, and so visible only as dull black lines on the latter plane, and as shining black scales when the slab is broken across. In tracing the same rock across the valley, still another curious uniformity of position was observed. The great majority of the scales lie with their flat surface, the face *O*, normal to the line of strike, and the longer diagonal, here greatly elongated, parallel with the dip, a phenomenon entirely comparable with the "stretching" of gneiss, and indicating a pressure and an incipient structure at right angles to the present one.

Microscopically the rock shows exactly the same scaly coal-dusted mass, consisting largely of muscovite plates irregularly bounded, as does the schist adjoining the limestone, *d*, p. 269, only on a slightly larger scale. The biotite crystals are also bordered in the same way by a layer of larger and purer muscovite scales, but not so constantly, nor is the layer so broad and regular.

The mica crystals are true biotite (meroxene, $\rho < v$), as proved by study of cleavage scales. Some slides show in abundance grains of opaque black ore with some grains partly changed to an opaque white; others, in place thereof, are grains of exactly similar size and arrangement of an opaque yellowish white material; I judge therefore the former to be menaccanite, the latter leucoxene. Limpid dodecahedral garnets, magnetite and pyrite also occur. The only microscopical distinction between the upper and lower schists is in the somewhat larger size of the constituents, and a slightly greater clearness of crystalline texture in the upper, so that one can affirm more certainly the absence of any clayey matter. Macroscopically the upper schist is somewhat thicker bedded, of more uneven surface. A lens is hardly needed to see the muscovite scales on the surface of the slabs, and the biotite and garnet are conspicuous and abundant accessions, instead of being only minute and, in the case of garnet, also rare.

4. *The synclinal north of the brook in the Williams pasture.* North part of map, fig. 2.—Within the area just described the

rocks dip mostly to the east, while north of the brook the structure is decidedly different. A section east and west through the woods shows a great synclinal of the quartzite in the argillite.

Following down the brook from the limestone to where the woods end and then skirting the latter for a few rods north to where the first wood road enters them, a little way in and at the first outcrop on the south side of the road, there is a well exposed contact of the argillite beneath and the quartzite above; strike N. 20° E., dip 20° W.; the argillite flat fissile, with few chloritized garnets; the quartzite a dark gray indurated sandstone becoming coarser higher up. The two beds seem to be plainly conformable. The argillite can be followed north to a point in the bluff opposite C. Frary's house with uniform westerly dip beneath the quartzite, and on the west of the latter the argillite is found dipping easterly beneath it, though the junction is covered. I imagine this synclinal is cut off on the north by a fault along the bed of Fall river, but the rocks are covered here. Directly opposite the limestone across the brook the quartzite contains dodecahedral garnets 10 to 11^{mm} across, bordered by chlorite.

5. *The outcrop along Fox Brook to the south of the Williams section.*—Behind the first house on the road over West Mountain, after leaving the village, there is seen from the road a bare bluff of blue till, and below this an outcrop in the brook of Triassic sandstone; twenty rods above, the quartzite rests conformably upon the argillite, which contains a few garnets just below the junction. It strikes N. 60° E. and dips 20° E., and the boundary is thus pushed east by the whole width of the Williams section, though the fault which separates them can not be exactly located.

[To be continued.]

Art. XXXVI.—*On the Circular Polarization of certain Tartrate Solutions*—III; by J. H. Long.

In the number of this Journal for October, 1889, I described certain peculiarities of solutions of potassium antimony tartrate when mixed with carbonates, borates, phosphates or acetates in amounts insufficient to produce immediate precipitation. The specific rotation of this tartrate is very high, being, (for C = 5) $[a]_D = 141°{\cdot}273$. No other metallic tartrate approaches this rotation. It was shown in the paper referred to that the addition of sodium carbonate in small amount decreased the specific rotation to 55°·795, and this without precipitation of

the antimony. Other salts produced a marked decrease, but less than that by the carbonate.

As a problem of chemical dynamics this phenomenon possesses considerable interest as bearing on the general question of the nature of solutions, and I concluded to make it the special subject of an investigation, the chief points of which are given below.

Experiments with sodium carbonate.

For each test five grms. of the tartrate were dissolved in about 70 c.c. of water by aid of heat and then cooled to 20° C. or below. Definite amounts of the carbonate, pure and dry, were dissolved in water and added to the tartrate, the mixture being then diluted to exactly 100 c.c. at 20° C. By careful work it is possible to prepare clear solutions containing, with the five grms. of the tartrate, a gram, or more, of the anhydrous carbonate. With much greater amounts precipitation usually takes place before the polarization can be observed.

In the table below the solutions numbered 1 to 5 inclusive remained perfectly clear during several hours and were polarized in two to four hours after preparation. Numbers 6, 7 and 8 became slightly turbid and finally deposited a precipitate. The rotations were observed after twenty-four and forty hours. In nearly all cases some differences were observed in the tests made twenty-four hours apart. Such differences became very plain when the first test was made as soon as possible after the preparation of the solution. In order to show this I made cold solutions of the tartrate and carbonate, brought them to 20°, mixed and diluted quickly with the small amount of water necessary to make 100 c.c. After gentle shaking, the mixture was poured into a 400^{mm} tube, kept at 20° by water, and polarized within five minutes. The results found were very singular and interesting. They are given under numbers 9, 10 and 11. The three solutions remained perfectly clear during several hours. At the end of twelve hours number 9 had deposited nothing, but after twenty-four hours an unweighable trace separated out. Number 10 deposited nothing until after twenty-four hours. Number 11 was clear during two hours but in twelve hours a precipitate settled out, leaving the supernatant liquid perfectly clear. In all the above cases the precipitate appeared very much less than called for by the equation:

$$2KSbOC_4H_4O_6 . H_2O + Na_2CO_3 = 2KNaC_4H_4O_6 + Sb_2O_3 . H_2O + CO_2$$

Analysis of the precipitate showed it to have the composition given when dried at 100°. For the five grms. of the

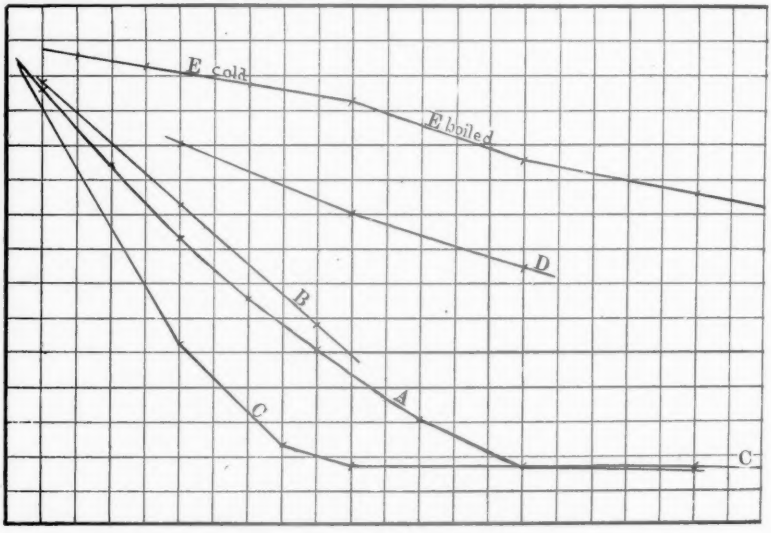
tartrate taken, 0·7982 grm. of the carbonate should be required for complete precipitation. Analysis of the supernatant liquid showed in all cases much of the antimony in solution.

It was noticed that a slight elevation of temperature produced a copious precipitation with escape of CO_2, in cases, and to test fully the action of heat, solutions were made and mixed hot. The mixture was kept one hour on the water bath and then filtered, the cool filtrate being made up finally to 100 c.c. at 20°. The results found in these tests are given below opposite numbers 12 to 18 inclusive.

No.	Na_2CO_3	a_D	KSbOT in 100 c.c	a_D for KSbOT + KNaT.	a_D for complete precipitation by Na_2CO_3.	
1	·1 grm.	25°·170	4·496grm.	27°·941	25°·132	
2	·3	20·690	4·226	24·417	----	
3	·5	16·628	3·482	20·764	12·853	
4	·7	13·535	2·838	17·624	----	
5	·9	10·250	2·023	13·607	3·767	
6	1·2	6·136	1·458	10·870	3·767	
7	1·5	3·510	·689	7·094	3·767	
8	2·0	3·301	·219	4·824	3·767	
9	·1	25·582	5·000	28·207	25·132	5 minutes.
9	·1	25·580	5·000	28·207	25·132	30 "
9	·1	24·480	5·000	28·207	25·132	12 hours.
10	·5	18·620	5·000	28·207	12·853	5 minutes.
10	·5	17·930	5·000	28·207	12·853	30 "
10	·5	16·670	4·716	26·814	12 853	40 hours.
11	·9	11·570	5·000	28·207	3·767	5 minutes.
11	·9	11·500	5·000	28·207	3·767	10 "
11	·9	11·132	5·000	28·207	3·767	25 "
11	·9	10·550	5·000	28·207	3·767	65 "
11	·9	10·339	3·569	21·188	3·767	12 hours.
12	·1	24·185	4·442	25·473	25·132	
13	·5	10·500	2·360	15·245	12·853	
14	·8	4·580	1·057	8·908	3·767	
15	1·0	3·568	·634	6·828	3·767	
16	1·5	3·495	·317	5·297	3·767	
17	2·0	3·495	----	----	3·767	
18	5·0	3·380	----	----	3·767	

From the table, and more readily from the curve marked A, in which the ordinates represent rotations and the abscissas amount dissolved, it will be seen that with the increase in the amount of carbonate added there is a decrease in the rotation. At first the decrease is nearly directly proportional to the amount of carbonate, but later, after the addition of enough to produce precipitation, the change in the rotation is less rapid. If we consider the first tests made with solutions 9, 10 and 11 it will be seen, as shown by curve B, that the decrease in the

angle of rotation varies regularly with the amount of added carbonate, the reaction not being at all obscured by precipitation. A molecular re-arrangement of some sort, undoubtedly an interchange of bases, must take place here. In the solutions prepared at the boiling temperature the decrease in the rotation is rapid until we pass the one containing ·8 grm. of the carbonate, which is theoretically sufficient for complete precipitation. In the solutions with larger amounts of the carbonate the change in the rotation is slow, as shown in the curve C. In the fourth column of the table above I give the amounts of potassium antimony tartrate left in solution, as determined by precipitation of the antimony as sulphide, and



calculated on the assumption that it is held as tartrate and not as antimonite or other compound. In column five are given the rotations calculated for these amounts of the antimony potassium tartrate plus that of the sodium potassium tartrate formed corresponding to the decrease in the other. In column six are given results calculated on the assumption that the added sodium carbonate precipitates antimony in the proportion given in the equation above. On this assumption for solutions containing more than ·7982 grm. of the carbonate the rotation should be that of the Rochelle salt equivalent to 5 grms. of the antimony compound taken. In the values given I have not taken into consideration the slight decrease in the

rotation of Rochelle salt in presence of excess of sodium carbonate.

But the calculated rotations approach those of actual observation only in the cases of the solutions with 0·1 grm. of carbonate, and in those with very large amounts of the latter, observed after long standing or boiling. No simple relations can therefore be traced in this way, and it is evident that a part of the antimony must be held in solution in some other way than as tartrate.

In mixing the solutions at a low temperature no precipitate was formed and no CO_2 given off. It is well known that the addition of acids to tartrate solutions decreases their rotation, mainly perhaps, from formation of bitartrate, and the idea suggested itself that this may be the action of the carbonic acid in the present mixture. An experiment tried with Rochelle salt after saturation with the gas failed to show, however, a lowered rotation. Slightly lower results were found by mixing the Rochelle salt with sodium bicarbonate.

That an important reaction takes place in solution can, however, be shown in another way. I prepared several solutions of the potassium antimony tartrate containing exactly 5 grm. in something less than 100 c.c. of cold water. To one of them a little litmus was added, after which a solution of sodium carbonate of exactly 2 per cent strength was run in from a burette. An alkaline reaction did not appear immediately, but the final change of color was not sharp enough for an accurate determination. Another solution was tried with phenol-phthalein, and here good results were found. In several trials between 74 and 78 c.c. of the carbonate solution were required for coloration. If the assumed equation of decomposition is correct, for 5 grms. of the tartrate we need practically 0·8 gram of the carbonate. This amount is contained in 40 c. c. of the solution used and it required nearly double that volume for coloration, which reaction suggests the formation of a bicarbonate if we bear in mind that such salts are neutral to phenol-phthalein. If it is also taken into consideration that in our titration a little gas is readily lost by agitation, it will be seen that practically the proper amount of alkali is added to complete the reaction above. From these tests it is apparent that a reaction between the tartrate and carbonate begins immediately on the addition of the latter, and also that the liberated CO_2 is held as bicarbonate or in other form with metal and neutral to the indicator. The following equation may express what takes place:

$$2KSbOC_4H_4O_6 + 2Na_2CO_3 + 2H_2O = 2KNaC_4H_4O_6 + Sb_2O_3.H_2O + 2HNaCO_3;\ \text{or} = 2KNaC_4H_4O_6 + 2SbONaCO_3 + 2H_2O.$$

If we calculate the theoretical rotation from this equation much closer results will be obtained than are given in column six of the above table, where only half as much carbonate was supposed to take part in the reaction. These equations would suggest an explanation of the behavior of solutions 9, 10 and 11, on standing. We may suppose at first a condition of equilibrium reached in which $HNaCO_3$ or $SbONaCO_3$ exists in solution. This equilibrium is destroyed by standing or by slight change of temperature so as to liberate CO_2 and permit the Na_2CO_3 formed to react on a fresh portion of the tartrate, giving further reduction in the rotation. When the rotation finally becomes constant quite different amounts of antimony may be left in solutions of the same original strength, as shown in the fourth column of the table, opposite numbers 5 and 11. The amount of antimony finally precipitated and the rapidity with which it precipitates seem to depend to some extent on the mechanical agitation which the solution receives.

Further light is thrown on the question of decomposition by the experiments next to be explained.

Experiments with sodium acetate and phosphate.

As I have before shown, acetates decompose the potassium antimony tartrate solution slowly in the cold but rapidly when heated. A solution containing 5 grms. of crystallized sodium acetate with 5 grms. of the tartrate in 100 c.c. gave, at 20°, $a = 25°{\cdot}745$, while one with 10 grms. of the acetate gave $a = 24°{\cdot}676$ instead of $28°{\cdot}207$. Later tests made with solutions mixed at the boiling temperature gave these results for the filtered solutions, represented by the curve D, where the abscissas have ten times the value they have in the others:

In 100 c.c. Tartrate.	Acetate.	a_D
5 grms.	5 grms.	$22°{\cdot}125$
5	10	$18°{\cdot}140$
5	15	$14°{\cdot}892$

These solutions were found to be strongly acid and by subjecting them to distillation I obtained a small amount of acetic acid. The precipitates were analyzed and were found to have the same composition as produced by the carbonate, viz: $Sb_2O_3 . H_2O$. The reaction taking place is probably this:

$$2KSbOC_4H_4O_6 . H_2O + 2NaC_2H_3O_2 = 2KNaC_4H_4O_6 + Sb_2O_3 . H_2O + 2HC_2H_3O_2.$$

As a further test I prepared a solution with 10 grm. of the acetate and 5 of the tartrate and heated it for one hour on the water bath. It was then filtered. The filtrate, after addition

of phenol-phthalein, was titrated with half normal KOH, of which exactly 30 c.c. was required to give color. This is the volume needed to neutralize the acid or precipitate the antimony of the last equation. The solution remained quite clear until about 12 c.c. of the alkali had been added, when it became opalescent and finally turbid before the color reaction appeared. In an experiment with 5 grms. of the tartrate in cold solution without the acetate exactly the same amount of alkali was required for coloration, but an opalescence appeared immediately, and no actual precipitation occurred until all the alkali had been added. This experiment amounts, of course, to a titration of the tartrate:

$$2KSbOC_4H_4O_6 + 2KOH = K_2C_4H_4O_6 + Sb_2O_3 . H_2O.$$

Finally, the experiment was varied in this way. 5 grms. of the tartrate and 10 of the acetate were dissolved and mixed at a low temperature. Phenol-phthalein was added and then alkali to coloration. Now, as before, 30 c.c. was required to give color, but the reaction took place in a different manner, as a precipitate formed immediately and grew heavy as more alkali was added. This behavior seems to indicate that the antimony is held in a peculiar manner, partly at least, in the solution containing the acetate. Possibly a preliminary reaction is this:

$$KSbOC_4H_4O_6 + NaC_2H_3O_2 = KNaC_4H_4O_6 + SbOC_2H_3O_2,$$

the last being stable in cold dilute solution but decomposed by heat or alkalies,

$$2SbOC_2H_3O_2 + 2KOH = 2KC_2H_3O_2 + Sb_2O_3 . H_2O.$$

If the above equations express the truth we can readily account for the polarization phenomena. In fresh solutions prepared in the cold the rotation is decreased because of the abstraction of a part of the antimony to form acetate. In the boiled solutions, or in those prepared cold, after long standing, the rotation may be still further reduced by the action of free acetic acid on the tartrate. Some results obtained with solutions of sodium phosphate are given below:

In 100 c.c. Tartrate.	Phosphate.		a_D 3 hrs.	a_D 72 hrs.
5 grms.	0·2 grm.	cold.	27°·350	27°·345 no ppt.
5	0·4		26°·700	26°·727
5	0·7		25°·732	25°·690
5	1·0		24°·755	24°·850
5	1·5	boiled	21°·303	
5	2·0		19°·448	
5	5·0		11°·502	

These results are illustrated by the curve E. The solutions, after boiling, were strongly acid. Several tests were made with borax solutions in the same manner. They gave tests for free boric acid while the precipitate formed had the composition observed in the other cases.

From a consideration of the behavior of the several mixtures, I think it is plain that the explanation of the decrease in the rotation must be the same for all cases. This explanation is one which at first sight would scarcely be expected because of the practical silence of the literature on the subject of carbonates, acetates and phosphates of antimony. The last two have been described as stable in some of the older works. If we may assume that in these combinations the metal is held as SbO' the polarization phenomena can be readily accounted for. By mixing solutions of alkali phosphates, acetates, carbonates and borates with the tartrate in the cold there is probably first formed a temporarily stable antimony salt with corresponding amount of alkali tartrate. The observed rotation is due to this plus that of the unchanged potassium antimony tartrate. After decomposition by heat a small amount of free tartaric acid or bitartrate, with low rotation, must exist in the cases where acetic and phosphoric acids had been liberated in the reaction. In the solutions with large excess of carbonate the total antimony found probably exists in combination with sodium, the decomposing action of the carbonate being much greater than that of the phosphate, acetate or borate.

Experiments with potassium ammonium tartrate.

I have already shown that the rotation of solutions of potassium sodium tartrate is in general increased by addition of salts of potassium or ammonium and decreased by those of sodium and lithium. I have since carried out a similar investigation, using potassium ammonium tartrate as the active substance. This salt was freshly prepared from pure $KHC_4H_4O_6$ and NH_4OH and crystallized. In the following table I give a few of the results obtained which illustrate all.

20 grms. of $KNH_4C_4H_4O_6$ in 100c.c. gave at 20° $a = 24°{\cdot}680$, or $[a]=30°{\cdot}850$, which is somewhat lower than the value given by Landolt. In presence of inactive salts the rotation is altered as here shown.

In 100 c.c. with 20 grms. tartrate.		a_D	$[a]_D$	Deviation in $[a]$.
5 grms.	NH_4Cl	24°·525	30°·656	−0·194
10	NH_4Cl	24°·480	30°·600	−0·250
5	KCl	24°·710	30°·888	+0·038
10	KCl	25°·136	31°·420	+0·570
5	NaCl	23°·790	29°·963	−0·887
10	NaCl	22°·806	28°·508	−2·342

The molecular rotation of the several tartrates which come into consideration here are, (from Landolt's results and my own):

$K_2C_4H_4O_6 = 64°{\cdot}42$	$KNaC_4H_4O_6 = 62°{\cdot}34$
$(NH_4)_2C_4H_4O_6 = 63°{\cdot}04$	$KNH_4C_4H_4O_6 = 63°{\cdot}24$
$Na_2C_4H_4O_6 = 59°{\cdot}85$	$NaNH_4C_4H_4O_6 = 61°{\cdot}71$

On the general hypothesis of replacement in the tartrate molecule by excess of inactive salts these numbers show why the addition of NH_4Cl should produce but a slight change, while that of NaCl must produce a much greater one in the rotation of $NH_4KC_4H_4O_6$.

These results, like those obtained with the antimony compound, suggest the value of the polariscope method in the study of problems of chemical affinity. This method has been applied in a limited number of cases but the experiments above detailed indicate a direction in which it may be developed. That a certain interval of time is necessary to complete these reactions, even where no precipitates are formed, is shown by experiments 9, 10 and 11. The polariscope affords us a ready method, possibly the only method, of following these changes, which are of sufficient importance to merit further study.

Chicago, July 10th, 1890.

ART. XXXVII.—*A Rapid method for the Detection of Iodine, Bromine, and Chlorine in presence of one another;* by F. A. GOOCH and F. T. BROOKS.

[Contributions from the Kent Chemical Laboratory of Yale College—V.]

THE conditions under which iodine may be set free and separated quantitatively from hydrochloric and hydrobromic acid by the action of nitrous acid upon the acidulated solutions of the haloid salts have been recently studied in this laboratory.* We have endeavored in the work which is here described to so modify the quantitative process that the same principles of action may be applied rapidly and easily to the qualitative detection of iodine, bromine, and chlorine, without decreasing to too great a degree the delicacy of the indications. It was found in the work referred to that when sulphuric acid is added to the aqueous solution of a soluble chloride, bromide, and iodide, with care to keep the proportion of acid within certain limits and the dilution of the liquid sufficient, no very

* This Journal, xxxix, 293, and xl, 145.

appreciable volatilization of bromine or chlorine takes place during the complete expulsion of the iodine by boiling. For the quantitative separation of the iodine of 0·5 grm. of potassium iodide from a solution containing 0·5 grm. of potassium bromide and 0·5 grm. of potassium chloride it was found best to use from 1 to 2 cm^3 of strong sulphuric acid, and to introduce into the solution, measuring approximately 700 cm^3 in volume, 0·5 grm. of potassium nitrite, or its equivalent in nitrous fumes. It is obvious that work upon this scale is undesirable in rapid qualitative testing. For such purposes it is not a matter of moment that a portion of the substances looked for escapes the reaction, provided enough is left to furnish the indication sought. We planned, therefore, to attempt the separation of iodine from bromine and chlorine by applying the reaction just mentioned to small amounts of liquid in test-tubes, in the hope that the known losses of chlorine and bromine under the conditions would be proportioned to the strength of the solution, or in other words, that when the amounts of bromine and chlorine were very small they would escape volatilization, or that when large a sufficiency would remain to give strong tests.

The detection of the iodine is, of course, simple. We chose for this purpose the reaction with sulphuric acid and potassium nitrite. If the amount of iodine present is large it shows at once in this test, and the same portion may be treated further to separate the iodine. If the amount of iodine is small it may be found, as usual, by shaking the liquid with chloroform, or carbon disulphide or other appropriate solvent for iodine; or, in this case also, the portion under test may be utilized, if it is desirable, for the separation of the iodine, and for the detection of this element recourse may be had to the exposure of red litmus paper to the fumes of the boiling solution according to methods prescribed in the work referred to above upon the quantitative separation of the iodine,—the paper taking on a gray blue color when exposed to very minute traces of the vapor of iodine, and a proportionately deeper color as the amount of iodine increases. After the iodine is separated, bromine and chlorine are easily found if present. We selected as the most available method for detecting bromine the action of sodium hypochlorite upon the acid solution and shaking with the proper solvent. For the detection of chlorine we make use of a modification of the well known chlorochromic anhydride test.

As a preliminary step to the investigation of the reliability of our method of separating iodine from bromine, tests were made, for the purpose of securing definite points of comparison, upon the degree of delicacy of the hypochlorous acid test for bromine. In these tests measured amounts of a solution of potassium bromide were drawn from a burette into test-tubes.

To each portion were added a few drops of sulphuric acid, the liquid was diluted with distilled water to the level of a mark upon the tube indicating a volume of 10 cm^3, 0·5 cm^3 of chloroform, or of white carbon disulphide were introduced, and the whole was shaken after the addition of a drop of a dilute solution of sodium hypochlorite. The results of these tests are as follows :—

KBr taken.	Total Volume.	Ratio of KBr to total volume.	Color test in chloroform.	Color test in carbon disulphide.
0·0010 grm.	10 $cm.^3$	1 : 10000	Strong.	———
0·0005	10	1 : 20000	Pronounced.	———
0·0004	10	1 : 25000	Pronounced.	Strong.
0·0003	10	1 : 33000	Faint.	Pronounced.
0·0002	10	1 : 50000	Trace.	Faint.
0·0001	10	1 : 100000	Doubtful.	Trace.
0·0001	10	1 : 100000	None.	Trace.
0·00007	10	1 : 140000	———	Doubtful.
0·00007	10	1 : 140000	———	Doubtful.
0·0004	5	1 : 12500	Strong.	———
0·0003	5	1 : 16000	Strong.	———
0·0002	5	1 : 25000	Pronounced.	———
0·0001	5	1 : 50000	Trace.	———
0·00007	5	1 : 70000	None.	Faint.
0·00003	5	1 : 140000	———	Doubtful.

From these results it is plain, as Fresenius has pointed out, that clear white carbon disulphide is the more sensitive reagent, the delicacy of the test extending distinctly to one part in fifty thousand when chloroform is the solvent for bromine and to one part in one hundred thousand when carbon disulphide is employed.

In the following series of tests the bromide was subjected to the same treatment which it must undergo were iodine actually present and expelled as we proposed. To the solution of the bromide in a test-tube were added a few drops of dilute sulphuric acid and a few drops of a solution of potassium nitrite. The liquid was boiled, cooled, and treated with sodium hypochlorite as in the former tests, excepting that even after boiling for some time it was found to be necessary to introduce more of the hypochlorite than before to overcome the nitrous acid remaining in solution and to set free the bromine.

KBr taken.	Total Volume.	Ratio of KBr to total volume.	Color test in Carbon disulphide.
0·0010 grm.	10 $cm.^3$	1 : 10000	Strong.
0·0005	10	1 : 20000	Pronounced.
0·0004	10	1 : 25000	Pronounced.
0·0003	10	1 : 33000	Faint.
0·0002	10	1 : 50000	Faint.
0·0001	10	1 : 100000	Doubtful.
0·00007	10	1 : 140000	None.
0·00007	5	1 : 70000	Trace.

Evidently the presence of nitrous acid and the treatment by boiling do not interfere seriously with the delicacy of the test. The experiments of the following series were made similarly excepting that potassium iodide was added in varying amount to the solution of the bromide. In these tests a spiral of platinum wire was introduced into the test-tube to prevent too violent ebullition, and at intervals during the boiling the nitrite was added in solution, drop by drop, until the iodine was entirely expelled, care being taken to add a little more sulphuric acid toward the end of the separation to ensure completeness of action. The colorlessness of the liquid in the test-tube after this treatment is a fair indication of the entire expulsion of iodine, but when large amounts of bromide are present free bromine will color the liquid. Salts of iron or other substances which possess color naturally interfere likewise. In such cases, and indeed in all cases, the action of the escaping steam upon red litmus paper is decisive. In the experiments here recorded this test was applied to determine the absence of iodine from the liquid. The residue after the expulsion of the iodine was treated as usual with sodium hypochlorite and shaken with carbon disulphide.

KI taken.	KBr taken.	Total Volume.	Ratio of KBr to total volume.	Color in Carbon disulphide.
0·1000 grm.	0·0010 grm.	10 cm.³	1 : 10000	Pronounced.
0·1000	0·0004	10	1 : 25000	Pronounced.
0·1000	0·0003	10	1 : 33000	Pronounced.
0·1000	0·0002	10	1 : 50000	Faint.
0.1000	0·0002	10	1 : 50000	Faint.
0.1000	0·0001	10	1 : 100000	None.
0·0500	0·0005	10	1 : 20000	Pronounced.
0·0400	0·0004	10	1 : 25000	Pronounced.
0·0300	0·0003	10	1 : 33000	Pronounced.
0·0200	0·0002	10	1 : 50000	Faint.
0·0100	0·0001	10	1 : 100000	None.
0·1000	0·00007	5	1 : 70000	Trace.
0·0070	0·00007	5	1 : 70000	Trace.

These results indicate obviously that although the bromine is volatilized to some extent with the iodine it is nevertheless the case that the proportionate amount of bromine removed is dependent upon the absolute amount present, and that enough bromine always remains to permit correct inference as to the quantity originally present, the color test being more or less marked according as much or little bromide was in the solution at the start. The delicacy of the test is a trifle less than that in which the bromide is alone present and not subjected to the treatment which we employ to remove iodine, but the detection of one part of potassium bromide in fifty thousand is certain, and that of one part in seventy thousand possible. It appears, furthermore, that the increase in the amount of iodine present is without effect upon the sensitiveness of the test; for the bromine in 0·00007 grm. of potassium bromide was as

easily found in the residue remaining after the expulsion of the iodine from 0·1 grm. of potassium iodide as in that left after the expulsion of the iodine from 0·0070 grm. of the same salt, and the indications in the experiments in which the ratio of the iodine to the bromine remained the same while the absolute amounts of both varied are precisely the same as those of the experiments in which the maximum amount of iodine remained unchanged throughout the variations in the amount of bromide used. The maximum amount of potassium iodide employed in these tests was 0·1 grm., but there is no reason to suppose that this amount is not far below the maximum which may be successfully handled in this process.

For the detection of chlorine we modified the well-known chlorochromic anhydride process so that the distillation may be performed in an ordinary test-tube. The substance to be tested is, if solid, placed in a large test-tube—$15^{cm} \times 2^{cm}$ is a good size—and treated with sulphuric acid and potassium dichromate in the manner to be described. The substance, if a liquid, is rendered alkaline, if necessary, by sodium carbonate and evaporated to dryness in the test-tube with care to remove all moisture from the sides of the tube. This operation is effected without trouble if the tube is inclined, as much as is possible without spilling the liquid, and agitated continually while the flame is applied to the higher parts The evaporation effected, a little powdered potassium dichromate is introduced through a funnel with care to prevent its touching the upper parts of the tube, two or three cubic centimeters of strong sulphuric acid are added, and a trap consisting of a straight two-bulbed drying-tube cut off about an inch from the large bulb is hung in the mouth of the test-tube, the precaution having been first taken to moisten the interior of the bulbs with water without wetting the wide, straight portion which hangs within the test-tube. If a chloride is present the evolution of chlorochromic anhydride begins as soon as this sulphuric acid touches the dry salts in the bottom of the tube, and gentle heating, with a little agitation, quickly completes the evolution of the chlorine compound. It is the function of the moisture in the bulbs to decompose the fumes of the chlorochromic anhydride and to retain the chromic acid thus produced. When more than a mere trace of chlorine is present the yellow drops produced in the moistened bulbs are, in the absence of a bromide, sufficiently indicative of the presence of chlorine in the original substance, but the delicacy of this test is much increased by washing out the bulbs with a little distilled water and adding to the solution, as Wiley recommends,* a few drops of a solution of lead acetate, which precipitates the yellow chromate or intensifies the color of the solution according to the amount of chromic

* Am. Chem. Jour., ii, 248.

acid acting. It often happens, when the temperature of the liquid in the test-tube rises a little higher than need be, that fumes of sulphuric acid pass into the bulbs to such an extent as to produce a white precipitate of lead sulphate when the lead acetate is subsequently added. In such cases the lead sulphate is easily dissolved by the addition of a little ammonic acetate in saturated solution, and gentle heating, and, on cooling, the yellow chromate is either precipitated or simply colors the liquid. It is advisable, however, as our experience proved, not to employ more of the ammonic acetate than the occasion requires, as it undoubtedly exerts some solvent action upon the lead chromate as well as upon the sulphate.

We proceeded to test in the manner described the applicability of this process by first testing the action upon solutions of pure potassium chloride.

KCl taken.	Final volume.	Reaction obtained.
0·0030	5^{cm3}	Marked precipitation.
0·0020	5	Marked precipitation.
0·0010	5	Distinct precipitation.
0·0005	5	Distinct color.
0·0004	5	Faint color.
0·0003	5	Faint color.
0·0002	5	Faintest color.
0·0001	5	Doubtful.
0·0001	5	None.
0·0001	5	None.

It appears, therefore, that the chlorine in 0·0005 grm. of potassium chloride is found certainly, and that indications of chlorine in amounts of the chloride ranging as low as 0·0002 grm. are fairly evident in tests made upon the pure substance taken in solution, evaporated, and treated as described.

The effect of submitting the solution of the chloride containing also a known amount of potassium iodide to the process previously described for liberating the iodine, of then neutralizing the solution with sodium carbonate, evaporating to dryness, and treating with sulphuric acid and potassium dichromate, is shown in the following record. The potassium iodide used in these tests was prepared free from chlorine by the action of resublimed iodine upon iron wire and subsequent treatment with pure potassium carbonate. The nitrite was freed from chlorine by adding to its solution a little silver nitrate, faintly acidulating with nitric acid, and filtering off the chloride precipitated with a small amount of the nitrite.

KI taken.	KCl taken.	Final volume.	Reaction obtained.
0·1 grm.	0·0020 grm.	5 cm.^{3}	Distinct precipitation.
0·1	0·0010	5	Distinct color.
0·1	0·0005	5	Faint color.
0·1	0·0004	5	Faint color
0·1	0·0003	5	Faintest color.
0·1	0·0002	5	Faintest color.
0·1	0·0001	5	None.

The distinctness of the color obtained in this process seems to be diminished a little by the process of liberating the iodine, but the lowest reach of the test is not very materially different from that made upon the pure chloride. In the following similar tests made with mixtures containing beside the chloride potassium bromide alone, or the bromide as well as iodide, the phenomena observed were the same, excepting that the fumes of the bromine evolved when much bromide is present rise with the chlorochromic anhydride and, dissolving in the film of moisture in the trap, give to it their own characteristic color, and so obscure the effect of chromic acid. In these experiments, therefore, the washings of the bulbs were first rendered faintly ammoniacal and gently heated to destroy the free bromine, and then the solution was acidified with acetic acid and tested as described with lead acetate and ammonium acetate.

KI taken.	KBr taken.	KCl taken.	Final volume.	Reaction obtained.
—	0·1 grm.	0·0030 grm.	5 cm.^{3}	Marked precipitation.
—	0·1	0·0020	5	Distinct precipitation.
—	0·1	0·0010	5	Distinct color.
—	0·1	0·0005	5	Faint color.
—	0·1	0·0005	5	Faint color.
—	0·1	0·0004	5	Faintest color.
—	0·1	0·0003	5	Doubtful color.
—	0·1	0·0002	5	Doubtful color.
—	0·1	0·0001	5	None.
0·1 grm.	0·1	0·0010	5	Distinct color.
0·1	0·1	0·0010	5	Distinct color.
0·1	0·1	0·0010	5	Distinct color.

The evolution of considerable amounts of bromine appears, therefore, to diminish the delicacy of the test in some degree, but 0·0005 grm. of chlorine—the amount in 0·0010 grm. of potassium chloride—is indicated unmistakably in the presence of 0·1 grm. of potassium bromide, and 0·1 grm. of potassium iodide, and the test may probably be relied upon to show half that amount of chlorine. The potassium iodide, as already mentioned, was specially prepared for the work, and contained in the amounts which we used no recognizable trace of chlorine. The potassium bromide contained of chlorides enough to show an indication in 0·5 grm. of the salt. We were unable to find the chlorine in 0·2 grm. of the salt, and so considered it safe to employ half this latter amount in our experiments as being sufficiently free from chlorine for the purpose.

The process which we propose for the rapid qualitative detection of the halogens in presence of one another may be summarized briefly, as follows:

To detect iodine, the solution of the substance under examination is acidulated with dilute sulphuric acid and treated with a drop or two of a solution of sodium or potassium nitrite free

from chlorine. Unless the amount present is small, the iodine shows itself in the color of the solution and in the vapors which escape. Small amounts may be found by shaking the liquid with carbon disulphide in the usual manner, or, when economy of material is desirable, by gently heating the prepared solution and testing the escaping fumes with red litmus paper, thus utilizing the same portion of material for the detection of the iodine and for its separation preparatory to testing for bromine and chlorine.

To remove the iodine previous to making the tests for bromine and chlorine, a few drops of dilute sulphuric acid and a like amount of a dilute solution of sodium or potassium nitrite (prepared free from chlorine as described) are added to the solution of the substance in a test-tube, and the liquid is boiled with constant agitation. When the color of iodine disappears from the fumes and the solution, a drop or two more of sulphuric acid, and of the nitrite, are again added, and the boiling is repeated. When the escaping steam no longer gives to red litmus paper the characteristic gray blue color due to the action of iodine, the process of separation is complete.

A portion of the solution thus prepared is tested for bromine by cautiously adding a dilute solution of sodium hypochlorite and shaking with colorless carbon disulphide.

The test for chlorine is made in a second portion of the solution from which the iodine has been removed. The liquid is neutralized with sodium carbonate or hydrate free from chlorine, evaporated to dryness in a test-tube and treated as described with sulphuric acid and potassium dichromate, the fumes of the chlorochromic anhydride which arise on gentle warming being condensed and converted to chromic acid by the film of moisture upon the interior walls of the trap. The trap is washed out with a very little distilled water (5 cm.^{3} are enough), and the washings made slightly ammoniacal to destroy free bromine, if necessary, and after gentle warming again acidified, are tested with lead acetate. If the yellow chromate is precipitated the presence of chlorine in the original substance is proved. If the precipitate is white, as is very likely to be the case, a few drops of a saturated solution of ammonium acetate are added with caution, and the whole is gently warmed to dissolve the white sulphate. On cooling the solution and shaking (or immediately if much chromic acid has been formed), the yellow chromate falls, or gives color to the solution according as the chloride was originally present in large or small amount.

The process is rapid and sufficiently exact for qualitative testing in general.

ART. XXXVIII.—*Metacinnabarite from New Almaden, California;* by W. H. MELVILLE.

AN excellent specimen of metacinnabarite was recently found in the quicksilver mine at New Almaden, Santa Clara County, California, and a portion of it was given me for examination. Metacinnabarite was never before known to occur in these deposits, although in neighboring cinnabar localities the amorphous mineral has been met with. This specimen carries finely developed and brilliant crystals which are admirably adapted for measurement on the goniometer.

In the ore seam where cinnabar has been deposited, there appears an argillaceous mass which has resulted from sediments derived from the decomposition of the country rock by solfataric action. This mass is not homogeneous but consists of gray and green particles, the former evidently a mixture of clay and partially decomposed rock constituents with a small amount of carbonates, the latter a silicate the composition of which is shown in the following analysis.

Analysis of the Green Silicate.

SiO_2	67·59
Cr_2O_3	5·31
Al_2O_3, Fe_2O_3	12·24
NiO	4·57
CaO	0·73
MgO	7·84
Alkalies	very little
	98·28

In justice to these figures it should be said that only 0·1225 gram of substance could be obtained in sufficient purity for study, and the little impurity which this sample contained could not be removed by Thoulet's solution; also alkalies could not be determined.

Throughout this sheet of soft argillaceous matter, or selvage, large quantities of metallic quicksilver easily seen by the naked eye are distributed, and bright red cinnabar often deeply coloring small areas of quartz has crystallized. Cinnabar is found mainly deposited on this selvage—on the specimen at hand about an inch thick—intimately mixed with quartz, thus forming a hard compact mass upon which have grown cinnabar crystals, and these in turn are coated with minute quartz crystals. To this quartz the acute apex of the metacinnabarite crystal is attached and consequently is always broken. The

genesis of this metacinnabarite was certainly subsequent to the deposition of the cinnabar, and groups of flat rhombohedrons of white semi-transparent calcite appear to have formed at the same time. Crystallized dolomite is common among the ores of New Almaden and to this a fibrous silicate, undoubtedly chrysotile, firmly adheres. Fine bluish opal and occasional spangles of pyrite complete the list of associated minerals.

One other brittle substance was discovered while picking out metacinnabarite for analysis. It forms almost perfect spheres of a brilliant black color, which volatilize at a high temperature in yellowish vapor with a strong bituminous odor. The substance is organic matter and curiously mercury does not enter into its composition. These spheres can be detected under the microscope imbedded in the faces of the crystals of metacinnabarite (fig. 2.) and some were obtained by sharply rapping the specimen.

The rather low specific gravity of metacinnabarite is thus accounted for in part. Again the presence of minute particles of quartz was unavoidable, and therefore the given value was also influenced to a slight extent by this cause. The crystals used for the determination of the specific gravity contained far less impurity than is recorded in the analysis which follows. The specific gravity was in two cases 7·095 and 7·142, or mean =7·118 almost identical with that of guadalcazarite, 7·15.

Analysis of Metacinnabarite.

				At. Ratio.	
S	13·68			0·855	
Hg	78·01	*S corresponding=	12·48 %	0·7801	
Fe	0·61		0·34	0·0218	
Co	trace				
Zn	0·90		0·44	0·0277	0·0549
Mn	0·15		0·09	0·0054	
$CaCO_3$	0·71		13.35		
Residue, quartz	4·57	S found	13·68		
Volatile organic matter	0·63				
	99·26				

For analysis 0·6237 gram of substance was available, and both the qualitative and quantitative study proceeded contemporaneously. The small errors of analysis are distributed between the sulphur and organic matter, where the sulphur is as usual a trifle too high. An uncertainty naturally exists in the determination of the organic matter. Selenium was looked for but its presence failed to be established.

The crystals belong to the rhombohedral system (Miller) and consist of two poles differently modified. The following forms were observed :

	Miller.	Bravais-Miller. ($h\ k\ l\ m$)	Naumann.
Analogue Pole.			
Basal plane	$\kappa(111)$	$\kappa(0001)$	$c : \infty a : \infty a : \infty a$
Positive hemi-rhombohedron	$\kappa(100)$	$\kappa(1\bar{1}01)$	$c : a : a : \infty a$
Negative rhombohedron	$\kappa(33\bar{2})$	$\kappa(0\bar{5}54)$	$\frac{1}{5}c : \infty : 1 : 1$
Hemi-scalenohedron	$\kappa(21\bar{1})$	$\kappa(1\bar{3}22)$	$\frac{3}{2}c : 3 : 1 : \frac{3}{2}$
Antilogue Pole.			
Negative hemi-rhombohedron	$\kappa(33, \bar{1}\bar{7}, \bar{1}\bar{7},)$	$\kappa(50, \bar{5}\bar{0}, 0, \bar{1})$	$50c : 1 : 1 : \infty$
Hemi-scalenohedron	$\kappa(31, \bar{1}\bar{7}, \bar{1}\bar{5})$	$\kappa(48, \bar{1}\bar{6}, \bar{2}, \bar{1})$	$48c : 1 : \frac{3}{24} : 24$
Hemi-scalenohedron	$\kappa(26, \bar{1}\bar{5}, \bar{1}\bar{2})$	$\kappa(41, \bar{3}\bar{8}, \bar{3}, \bar{1})$	$41c : 1 : \frac{4}{38} : \frac{4}{3}$

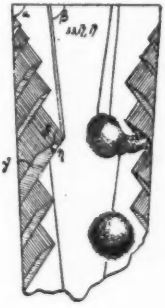
Angle of axes (Miller)=118° 11′ 20″
Axial ratio $c : a = 0{\cdot}2372 : 1$ (Naumann).

Measurements.

		Measured.	Calculated.
$111 \wedge 100$	=	15° 19′	
$100 \wedge 010$		26 29	
$100 \wedge 21\bar{1}$		4 15	
$111 \wedge 33, \bar{1}\bar{7}, \bar{1}\bar{7}$		94 10	94° 10′ 36″
$111 \wedge 31, \bar{1}\bar{7}, \bar{1}\bar{5}$		94 31	94 33
$111 \wedge 26, \bar{1}\bar{5}, \bar{1}\bar{2}$		94 42	95 17
$33, \bar{1}\bar{7}, \bar{1}\bar{7} \wedge \bar{1}\bar{7}, 33, \bar{1}\bar{7}$		119 28	119 28
$33, \bar{1}\bar{7}, \bar{1}\bar{7} \wedge 31, \bar{1}\bar{7}, \bar{1}\bar{5}$		2 6	
$33, \bar{1}\bar{7}, \bar{1}\bar{7} \wedge 26, \bar{1}\bar{5}, 12$		3 55	

Fig. 1.

Fig. 2.



The poles of the scalenohedrons in the negative hemisphere almost belong in the zone circles passing through any two poles of the negative rhombohedron, therefore, as shown in the figures the planes of the former do not exactly bevel the terminal edges of the latter. The faces of the former $x(26, \bar{1}\bar{5}, \bar{1}\bar{2})$ are tectonic and contain series of re-entering angles (fig. 2) which indicate the building up of that portion of the crystal rather than twinning. Otherwise striations are absent, and owing to the brilliancy of the plane surfaces sharp reflections of the signals on the goniometer were obtained. Fig. 2 was drawn with the aid of cross-hair and graduated stage of the microscope and in such position that the face $(33, \bar{1}\bar{7}, \bar{1}\bar{7})$ is parallel to the plane of projection. The following plane angles were read: $\alpha=86°\ 20'$, $\beta=82°45$, $\gamma=39$, $\delta=85°\ 30'$, $\eta=24°$. The relations of these angles with the elements of the crystal have not been made out. With the exception of $x(33\bar{2})$ all the observed forms are

represented in fig. 1, and actually occur on one crystal with equal regularity. Fig. 2 is the combination of $x(111)$ with the plains of the antilogue pole tabulated above. The distances of the poles of all the rhombohedral faces from the pole of (111) were measured on the same crystals and no doubt can possibly exist as to the system of crystallization. Viewed as they are implanted on the rock, the crystals present much similarity to tetrahedrons, but examination shows that the face of the negative rhombohedron in combination with the basal plane forms an isosceles and not an equilateral triangle. Besides the measured angle $\beta = 82° 45'$ the plane acute angle of $(33, \bar{1}\bar{7}, \bar{1}\bar{7}) = 14° 29' 40''$ was calculated from the fundamental angles. The crystals vary in length from $1{\cdot}24^{mm}$ to $2{\cdot}3^{mm}$ and in width from $0{\cdot}59^{mm}$ to $0{\cdot}97^{mm}$; possess a high metallic luster, black color, black streak with slight reddish tinge; are brittle with hardness about 2; and give the reactions for zinc and sulphide of mercury.

This mineral I consider metacinnabarite since the atomic ratios give a very improbable formula. Its specific gravity is much below that given to the species by Mr. G. E. Moore* 7·70—7·75 for the reasons stated above. On the other hand its somewhat close resemblance to guadalcazarite† in chemical and physical properties—for Castillo mentions rhombohedral crystals of this mineral—might point to its identity with this species. But it must be acknowledged to be metacinnabarite in composition with a small percentage of impurity of other sulphides such as would be naturally expected on precipitation and crystallization from solution. Again the crystals of metacinnabarite, many of which I have examined from localities in California as far back as 1882, are very indefinite and although they appear to be rough cubo-octahedrons, might really consist of the combination of basal plane and rhombohedron. Mr. S. L. Penfield‡ has described metacinnabarite crystals from California, and determines them to be hemihedral isometric forms. One measurement is there given, viz: $322 \wedge 3\bar{2}\bar{2} = 86° 54\frac{1}{2}'$ (mean of three) which approximates the angle $(\bar{1}\bar{1}\bar{1}) \wedge (33, \bar{1}\bar{7}, \bar{1}\bar{7}) = 85° 50'$, the supplement of which appears in the table above. It is possible that these two planes may form the combination I have indicated. No angle occurs on crystals in my possession near that of $211 \wedge 112 = 33° 15'$ to $36° 54'$ which Mr. Penfield found. It is barely probable that metacinnabarite is dimorphous. If it should happen that brilliant crystals of metacinnabarite from the Knoxville quicksilver district should be found, I firmly believe that their habit

* Dana's Mineralogy, App. I, 10.

† Ibid, App. II, 25.

‡ This Journal, June, 1885, p. 452.

could be reconciled with the symmetry of the crystals from New Almaden, the southern district.

It is through the kindness of Mr. Waldemar Lindgren of the U. S. Geological Survey and Mr. F. Von Leicht, the superintendent of the New Almaden quicksilver mines, that the material was available for this study.

Laboratory U. S. Geological Survey, Washington, D. C., June, 1890.

ART. XXXIX.—*On the Keokuk Beds at Keokuk, Iowa;* by C. H. GORDON.

THE exposed area of the Keokuk Beds is nowhere extensive. Their relations to the adjoining beds—the Burlington below and the St. Louis above—are everywhere marked by strict conformity, their separation being based solely upon lithological and faunal distinctions. Of these, the faunal characteristics especially are of such a nature as to mark this formation as one of the most important of the Lower Carboniferous group. The exposure at Keokuk is limited, being entirely due to the erosion of the Mississippi river and its small tributaries. Along the borders of these the limestone of the lower division usually presents a bold and smooth escarpment.

Outside of the Keokuk region where the beds were first studied, the most notable exposures occur at Crawfordsville, Indiana, and in southwestern Missouri. At the former locality they are 280 feet thick with a distinctively crinoidal and molluscan fauna.* In Missouri they contain valuable deposits of lead.

The general dip toward the south and west carries these beds from sight just below the mouth of the Des Moines, but a change of dip again brings them to view in the vicinity of Quincy, Ill., and at other places to the south. In some cases their appearance is due to faulting.

At Keokuk these beds consist of two well-defined divisions —the Lower or Calcareous and the Upper or Geode division.

II. *Geode Bed or Division.*

13. Fine, blue sandy layer. Crinoid bed No. 3. Resembles the arenaceous layers of the crinoid bed at Crawfordsville, Ind. *Seldom seen. Seventeen species of Poteriocrinidæ, Batocrinus lagunculus* Hall, *B. intermedius* W. and S., *B. similis* Hall, *B. originarius* W. and S., *B. mundulus* Hall, *Taxocrinus Wortheni* Hall. Thickness ..... 6 in.

* American Geologist, vol. ii, p. 407.

12. Soft, gritty shale, readily decomposing on exposure to atmospheric influences. Filled with geodes varying in size from one to four inches in diameter. Thickness..15 ft.
11. Shales, more calcareous, with occasional bands of limestone. Geodes fewer but larger. Thickness .....20 ft.
10. Limestone, hard, in thin variable layers. Thickness .... 2 ft.
9. Dark blue argillaceous shale. Contains no geodes. Thickness ..... 2 ft.

I. *Calcareous Division.*

8. Limestone, light gray, changing to light brown or yellow on exposure. Crinoid bed No. 2, sometimes called the Dorycrinus bed. *Batocrinus Nashvillæ* Troost, *B. biturbinatus* Hall, *Dorycrinus Mississippiensis* Rœmer, *Agaricocrinus Wortheni* Hall. *A. Americanus*, var. ——? *Barrycrinus tumidus* Hall, *Archimedes Owenia-ana* Hall, etc. Thickness .....1 to 2 ft.

Lenticular layers, prolific in crinoids, are sometimes found intercalated between 7 and 8.

7. Hard blue limestone; layers thin. Thickness.....3 to 5 ft.
6. Heavy dark blue limestone with nodules of chert. Fish bed No. 2. Thickness.....2 to 4 ft.
5. Blue subcrystalline limestone in layers 6 to 12 inches thick, alternating with similar layers of shales. Single valves and casts of *Spirifer Keokuk* Hall, abundant. Thickness.....8 to 15 ft.
4. White or light gray massive limestone called White Ledge by the quarrymen. Fish bed No. 1. Thickness. 4 ft.

At this point the partings frequently contain crinoids, while in some places a thin crinoidal layer is found resting upon the rolling cherty surface of the layer below. *Actinocrinus*, *Agaricocrinus Americanus* Rœmer, *Barycrinus magister* Hall, etc.

3. Impure shaly limestone with occasional bands of chert. Contains pockets of calcite in large beautiful crystals. Thickness ..... 6 ft.
2. Light gray comparatively soft limestone. Crinoid bed No. 1. Species numerous. *Agaricocrinus Americanus* Rœmer, also two varieties. *Actinocrinus pernodosus* Hall, *A. Lowei* Hall, *Batocrinus lagunculus* Hall, *Platycrinus Saffordi.* Thickness.....6 in. to 1 ft.
1. Massive blue or drab subcrystalline limestone. Occasional specimens of fish teeth belonging to the genus *Chitonodus.* Thickness..... 3 ft.

The parting between this and the beds below filled with stems and joints of *Eucladocrinus.*

Transition Beds.

Limestone in thin layers; cherty. Thickness exposed 6 ft. *Platyceras fissurella* Hall, *P. equilatera* Hall, *Palæcis obtusus* M. and W., *Batocrinus planodiscus* H., etc.

The Calcareous division consists of forty to sixty feet of limestone in layers varying from three inches to four feet, and separated by one to six inches of clay or shale partings. The thicker beds and those furnishing the best building stone occur in the lower portions of the division. One of these (No. 4), a very pure white, subcrystalline layer from three to four feet thick, called the White Ledge by the quarrymen, supplied the stone for the noted Mormon temple at Nauvoo. Another lower bed, separated from the White Ledge by six feet of shale and rotten limestone, sometimes furnishes an equally good if not better stone for general use. Below this the layers of the transition beds are thin and abound in chert.

Cherty bands occur at various intervals throughout the division. They have a concretionary structure, and vary in color from a dark drab to white, though usually more or less mottled. They are sometimes quite prominently discolored by included fossil fragments. The limestone layers often become cherty above with an uneven rolling surface. The more important chert masses have the general appearance of a sedimentary deposit. Nodular masses, however, frequently occur in various forms in the limestone beds. In some cases the siliceous material is distributed about some fossil fragment. In others they present the appearance of having taken the place of a cavity in the stone. The surface of contact is often distinct, the chert separating freely from the limestone, but adjacent parts of the latter are more or less altered to a cherty condition. These nodules have an eel-like form with often one or more bends and are not always parallel to the plane of bedding. A section shows a mottled, grayish white chert on the outside distributed in bands about an inner core of granular material made up principally of fossil fragments in a comminuted condition.

The chert beds, aggregating forty feet, which immediately underlie this division were included in it in Hall's Report* but subsequently removed to the Burlington by White.†

The appearance of these bands of chert at varying intervals from the Lower Burlington to the St. Louis limestone inclusive has been commented upon by White, though no explanation of their origin has been attempted.‡ Worthen

* Geological Survey of Iowa, 1858, vol. i, part 1, p. 94.

† Geological Survey of Iowa, 1870, vol. i, p. 203 (note).

‡ The investigations of G. J. Hinde, of the British Museum, on various cherts over the world led him to the conclusion that they are of organic origin. "The chert from the Carboniferous limestones of Ireland was all made chiefly from the siliceous spicules of sponges and the silica of silicified fossils has the same source." —This Journal, III, xxxiv, 405. See also vol. xxxvi, 73. Dr. M. C. White, of New Haven, made the earliest observations upon chert of the "Subcarboniferous limestone of Illinois," and the hornstone of the Corniferous and Black River beds. His paper will be found in this Journal (1862) II, xxxiii, 385. Dana also discusses the subject in his Manual on pages 267, 261, and 305.

attributed them to the intrusion of water charged with siliceous material from below. The accession of siliceous material to the waters of that epoch, however caused, resulted in the more or less complete extermination of the life characterizing the preceding epoch. Upon the restoration of normal conditions, however, a profusion of forms again appears though marked by variations in type and form. This tendency toward extinction may be observed in the smaller as well as the more important chert beds. The crinoidal facies of the first crinoid bed is essentially different from that of the second, while that of the third is unlike either. The destructive effect of excess of siliceous material represented in the Geode bed is especially noticeable in the paucity of species that were able to survive it. The almost complete extinction of the Actinocrinidæ is especially remarkable.* Not only is this true of crinoidal life but it has been remarked that a profusion of fish remains is nearly always accompanied by greater or less quantities of chert. The obvious connection existing between the presence of the chert and the extinction of previously existing species is certainly of great interest both from dynamical and evolutionary standpoints, though at present little understood.

At some of the partings in this division the upper surface of the lower stratum shows decided evidences of erosion. The limestone matrix has in some cases been worn away, leaving the fossils projecting one-half to one inch above the general surface. The rock-surface is usually, in these cases, much discolored and altogether its appearance seems to indicate changing submarine currents.

The upper division or Geode bed consists principally of argillaceous shale varying to an impure shaly magnesian limestone. The lower portion is more calcareous, sometimes including thin layers of tolerably pure limestone. An abundance of siliceous matters occurs here in the form of goedes which, with the exception of a few feet in the lower part, are disseminated throughout the formation. They are generally smaller and thicker in the middle and upper portions of the bed, while in the more calcareous layers below the geodes are large and contain more perfectly formed crystals.

The formation contains three crinoid beds quite clearly distinguished from each other in the character of their forms. Outside of these horizons crinoids sometimes occur, but sparingly.

The third bed, No. 13, of the section has not been found outside of a single locality in the lower part of the city discovered by Mr. L. A. Cox. Most of the species obtained from this bed were new and belong to the Poteriocrinidæ, evi-

* Keyes, American Naturalist, March, 1890, p. 243.

dently allying this stratum with the crinoid bed at Crawfordsville, Ind., while the resemblance is still further enhanced by the lithological character of the stratum. At the above locality there are twenty-five feet of fossiliferous shale underlying the crinoid beds and followed downward by two hundred feet of limstone and shale.* Now while at Crawfordsville the beds are marked by the Poteriocrinidæ, at Keokuk the fauna of the lower division is essentially Actinocrinoidal in aspect. The most common forms occurring in the lower division at Keokuk, viz: *Batocrinus Nashvillæ*, *B. biturbinatus*, *Actinocrinus pernodosus* and *Agaricocrinus Wortheni*, are absent at Crawfordsville, while even the ubiquitous *Agaricocrinus Americanus* is not recognized in the corrected lists of fossils from that locality.

We are disposed therefore to consider it as not improbable that the crinoid beds at Crawfordsville and the associated shale are the stratigraphical equivalent of the Geode bed and its associated layers at Keokuk.

The second crinoid bed is known as the Dorycrinus Bed, from the abundance of a single species of that genus, *D. Mississippiensis*.

The interest attaching to these beds centers largely in their Radiates of which the Crinoidea are the most prominent. The following table gives approximately the genera and number of species and their relations at Keokuk and Crawfordsville:

Genera.	Total Species.	At Keokuk.	At Crawfordsville.	Species common.
Actinocrinus,	6	5	--	
Agaricocrinus,	6	3	1	
Batocrinus,	13	7	2	*B. Indianensis.*
Barrycrinus,	15	9	2	
Calceocrinus,	4	2	1	
Catillocrinus,	2	--	1	
Cyathocrinus,	11	2	5	
Decadocrinus,	2	1	1	
Dichocrinus,	5	3	2	*D. ficus.*
Dorycrinus,	4	4	--	
Eretmocrinus,	5	3	--	
Eucladocrinus,	1	1	--	
Eupachycrinus,	1	1	--	
Forbesiocrinus,	2	1	1	*F. Wortheni.*
Goniasteroidocrinus,	2	1	1	
Graphiocrinus,	1	--	--	
Onychocrinus,	3	1	2	*O. ramulosus.*
Parisocrinus,	1	1	--	
Platycrinus,	5	4	1	*P. hemisphericus.*
Poteriocrinus,	3	1	1	
Rhodocrinus,	1	1	--	
Scaphiocrinus,	16	12	4	
Scytalocrinus,	4	-	3	
Stemmatocrinus,	1	--	--	

* Beachler, Am. Geol., vol. ii, p. 407.

Genera.	Total Species.	At Keokuk.	At Crawfordsville.	Species common.
Symbathocrinus,	3	3	--	
Taxocrinus,	3	2	1	
Vasocrinus,	1	--	1	
Woodocrinus,	6	3	2	
Zeacrinus,	1	--	--	
Number genera, 29	128	69	32	5

From this it appears that over one-half of the species of the formation occur at Keokuk, while at Crawfordsville the proportion is about one-fourth with only five species common. Out of the sixty-nine species observed at Keokuk, however, a large portion are rarely met with, while the hardness of the limestone matrix renders the collection and cleaning of fossils a comparatively slow and difficult process.

The collection of fish remains made here is an extensive one and may be grouped as follows:

	Total Species.	Species at Keokuk.		Total Species.	Species at Keokuk.
Cochliodonts,	26	20	Psammodonts,	1	1
Hybodonts,	17	17	Ichthyodorulites,	16	13
Petalodonts,	20	14			
			Total,	80	65

It is generally maintained against the evidence for the contrary from Coral Islands, as illustrated by Professor Dana, that limestone is a deep-sea deposit. The appearance of the Keokuk limestone in places shows very decided evidences of having been subjected to shallow water conditions. That littoral conditions are productive of arenaceous deposits alone would seem to necessitate the further proof that the debris derived from the neighboring land surface is distinctively arenaceous in character. That this is generally so is readily seen, but that it is always so can hardly be admitted. The presence of crinoids in the Keokuk limestone has been accepted as conclusive of a deep water origin, since existing forms of this order are usually obtained far below the surface. Nevertheless we are disposed to consider the Keokuk beds in the vicinity of Keokuk as essentially a shallow water deposit. Toward the east where it impinges upon the Cincinnati axis it becomes decidedly arenaceous, but along its northern border in Iowa no such change is observed, its calcareous character being as marked as farther toward the south. Moreover the discovery of a piece of fossil wood in this formation at Keokuk would seem to imply (1) an adjacent shore line and (2) shallow water. This interesting specimen was obtained from No. 5, about 10 feet below the base of the Geode bed. It is a portion of a Sigillarian trunk.

Keokuk, Iowa.

ART. XL.—*Note on the vapor-tension of Sulphuric Acid, with the description of an accurate Cathetometer Microscope;* by CHAS. A. PERKINS, Ph.D., Associate in Physics, Bryn Mawr College.

IN the physical laboratory it is frequently necessary to measure small differences in the height of two objects, such as two columns of liquid, etc., and especially to measure changes of height; and several forms of apparatus have been designed for this work. The cathetometer is accurate for this purpose only when provided with two telescopes and when the objects to be measured are in the same vertical line, and then is not readily used if the points are less than about 10^{cm} apart Desiring to make some measurements of this nature, I made use of the following apparatus: A microscope of rather long focus is mounted upon a rigid vertical brass column and is carried by a vertical micrometer screw, reading to $\frac{1}{200}^{mm}$. Immediately in front of the object glass and covering one-half of it, is placed a small total reflecting prism, so adjusted that when the microscope is focussed upon one object, the prism throws into the field the image of an object vertically above or below the second, but on a level with the first. If the objects to be measured are situated upon the same level, they will thus be superimposed; if not at the same level, they will come successively to the center of the field, by moving the micrometer through the necessary distance. With this apparatus, measurements may be made in which the probable error of a single setting is considerably less than $\frac{1}{200}^{mm}$ and in which the motion is a simple vertical one as if the two objects were in the same vertical line. The principal difficulty encountered is to bring both objects into focus at the center of the field. For this it is desirable to have one of the objects movable and to perform the adjustment by moving this object, but it is quite possible to make the adjustment when the objects are connected, as the two legs of a U-tube.

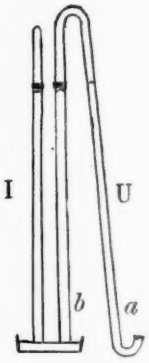
I have made use of this apparatus to measure the vapor tension of sulphuric acid. This liquid has some properties fitting it to be used in pressure gauges, either by itself or in connection with mercury.* I desired to use it for this purpose in a place where its vapor tension if appreciable would be injurious.

The only experiment, so far as I know, upon the vapor tension, was made under the direction of Sir Wm. Thomson,

* Callendar, On the practical measurement of Temperature, Phil. Trans., vol. clxxviii, p. 161; and Bottomley, On a practical Air Thermometer with constant volume, Phil. Mag., ser. V, vol. xxvi, p. 149.

and consisted in proving that the tension does not change much between 20° and 100° C.: the column of acid, by which the change of tension was measured, being 3^{mm} in diameter and terminated at one end by a vacuum and at the other by a bulb of gas which was kept as nearly as possible at the same temperature while the acid at the vacuum end of the tube was heated.*

My own plan originally was to take a U-tube, half filled with mercury, and after drying and exhausting the air from both legs, to observe the depression of mercury in one leg, when a drop of acid was introduced. In every case an elevation was observed, due to moisture leaking in through the cocks, or remaining on the glass and evaporating as exhaustion advanced; a form was therefore adopted which was free from cocks and in which the mercury could be boiled to drive off all moisture. It consists of two barometers. One is an ordinary cistern barometer (I), the other is an inverted U-tube with mercury in both legs. One end (*b*) dips into the same vessel as the tube I, the other (*a*) is recurved to prevent the admission of air, but allowing the acid to be introduced by a curved pipette or medicine dropper. The height of the column (*b*) in U is compared with that in I, before and after admitting acid into U through *a*. The internal diameter of the tubes is about $0{\cdot}8^{cm}$. In filling the U-tube, it is exhausted by a Sprengel pump and heated strongly. When cool, a little mercury is introduced and boiled and this operation is repeated till the tube is full. Unless this precaution is taken, the acid in rising through the tube, carries up air, which causes a depression of the mercury.



The acid was purchased of Queen & Co. as pure concentrated acid, but not absolutely anhydrous.

In making the measurements from three to five readings were made of the position of the meniscus in U and the same number for I: then acid was introduced into the other leg of U and the readings were repeated in the same order. The mercury column is illuminated from behind and a ring of black paper, sliding on the tube, is adjusted as near as possible to the top of the meniscus, allowing only a thread of light to pass over the top of the column. Unless this is done, reflections will make the top of the column uncertain. Where it is possible, the method of using the image of a black point and

* Encyc. Brit., 9th ed., Article "Heat."

its reflection, as done at Breteuil, leaves nothing to be desired; but I could not work with large enough tubes, and errors of setting were not my principal errors.

Measured in this way, my three best measurements gave for the vapor tension:

Difference of U and I in 200ths mm. Before admitting acid.	After.	Difference in mm.
31	33	+·01
9	11	+·01
−12	−13	−·005

This result is considered to be purely negative, as errors due to the change of the height of the barometer during the experiment and those introduced by irregularities in the capillarity of the mercury (in spite of shaking the tube) would be sufficient to account for the measured tension. A larger tube would have avoided some of the trouble, but would have increased very much the labor of manipulation.

In several other experiments, attention was carefully fixed upon the top of the mercury column in the tube *b* just as the acid rose through the other tube (*a*), in order to observe any instantaneous movement of the column. The movement, if any, was very slight—certainly not in excess of the above measurements. I therefore conclude that the tension is not greater than about ·01mm.

Art. XLI.—*Experiments upon the Constitution of the Natural Silicates;* by F. W. Clarke and E. A. Schneider.

During the past six years the constitution of the natural silicates has received a good deal of attention in the laboratory of the United States Geological Survey. A number of papers have been published by one of us, partly theoretical and partly analytical; but the evidence so far considered has been drawn only from careful analyses of various minerals, and a study of their obvious relations, their associations, and their alteration products. Within certain limits the results obtained have been satisfactory and suggestive; but in several cases it was found that ordinary analysis failed to discriminate between possible alternative formulæ; and it was plain that the uncertainties could only be cleared up by new lines of experimental investigation. With such investigations the present paper has to do. Sixteen minerals, including varieties, all of the magnesian group, have been examined; and it has been found quite possible to separate some of them into distinct fractions of definite

character in such a way as to shed much light upon their inner chemical structure. In general, the methods which have been employed by us are not new, except in their application to the silicate problem; but in their analogies to the processes used for the elucidation of organic compounds, we believe that they will be found interesting.

In brief, our mode of procedure has been as follows: First, each mineral, selected and purified with great care, has been completely analyzed; and in each case enough material was ground to a uniform sample to suffice for all subsequent experiments. Secondly, each mineral has been subjected to the action of *dry* hydrochloric acid gas, under quantitative conditions. For this purpose a quantity of material was weighed out in a platinum boat, which was then placed in a glass tube and heated in a stream of the dry gas until, after repeated weighings, constant weight was attained. The sample was then treated with water and a drop or two of nitric acid, and the soluble constituents of the mass were determined by the usual methods of analysis. In every instance a sample was thus treated at a temperature between 383° and 412° C., but in some cases other temperatures were studied also. For heating the tubes an ordinary combustion furnace was used; and the temperature was kept within the indicated range by placing on one side of the platinum boat a sealed capillary tube containing lead iodide, melting point 383°, and on the other side a tube containing zinc, which fuses at 412°. The flames of the furnace were then so adjusted that the iodide fused, while the zinc did not. For a higher range of temperatures, which was employed in some cases, the indicators similarly used were lead chloride, m. p. 498°, and silver iodide, m. p. 527°. These melting points are given according to Carnelley. As a rule, in each series of experiments the sample under treatment was weighed every two hours; and before reheating it was stirred with a fine platinum wire in order to expose a fresh surface to the action of the acid. By this mode of treatment different minerals are very differently affected; there being almost no action in some cases, and very notable action in others. With this action of gaseous acid, the action of aqueous hydrochloric acid upon each mineral was carefully compared, and some points of great importance were thus brought out. As a rule, one gram of mineral was treated with 75 cc. of fuming hydrochloric acid on the water bath, and the mixture was evaporated to dryness. When decomposition was not complete, the mineral was further treated with hydrochloric acid of sp. gr. 1·12 for three days or even longer, and the amount of action was ascertained and recorded. In several instances this treatment with aqueous acid was repeated after strong ignition of a mineral, and it was sometimes found that a

species previously soluble could be thus split up into a soluble and an insoluble part. In a number of cases ignition of a mineral caused the liberation of silica, which could afterwards be dissolved out with soda solution and quantitatively determined. For this purpose a solution of sodium carbonate, 250 grams to the liter, was employed. Finally, in almost every case the nature of the water in a mineral was investigated, by a study of the temperatures at which its several fractions were expelled. For low temperatures, an ordinary air-bath was used; for higher temperatures the minerals were heated in a stream of dry air, between indicators of known melting points, just as in the treatment with gaseous hydrochloric acid.

So much for the methods of research, which will be more clearly understood from a study of the details to be given presently. On the theoretical side we have adhered to the working hypothesis that the more complex silicates are substitution derivatives of normal salts, as has been suggested by one of us in several earlier publications. From this point of view the normal ortho-silicate of magnesium is the fittest starting point for discussion, and this salt is approximately represented by olivine. The purer forsterite was not available.

1. *Olivine.*

For this species the only material at hand was a supply of the chrysolite pebbles from near Fort Wingate, New Mexico. The mineral from this locality, we believe, has not been previously analyzed; and as it is rich enough in color and is sufficiently clear it is often cut as a gem. It has the characteristic color of the peridot, and is apparently quite free from inclusions. The analysis gave the following results:

SiO_2	41·98
Fe_2O_3	·51
FeO	5·71
NiO	·42
MnO	·10
MgO	51·11
H_2O	·28
	100·11

Only 0·05 per cent of the water was lost at 105°.

1·1027 grams of the mineral were heated in gaseous hydrochloric acid for twenty-two hours, and gained in weight 0·0157 grm. On leaching with water and a drop of nitric acid the following percentages of material went into solution:

MgO	1·47
Fe_2O_3	·43

Hence olivine, at the temperature of 383°–412°, is hardly attacked by dry hydrochloric acid; and the slight action here recorded may possibly be due to incomplete drying of the gas. The aqueous acid, on the other hand, decomposes olivine with great ease. On this mineral no other experiments were necessary for our purposes.

2. *Talc.*

The mineral studied was a typical, apple-green, foliated talc from Hunter's Mill, Fairfax County, Virginia. Analysis as follows:

SiO_2	62·27
Al_2O_3	·15
Fe_2O_3	·95
MgO	30·95
FeO	·85
MnO	trace
H_2O	4·91
	100·08

In detail, the water determination was as follows:

Loss at 105°	·07
Loss at 250°–300°	·06
Loss at red heat	4·43
Loss at white heat	·35

Hence the water is practically all constitutional.

Heated in dry HCl gas to 383°–412° for fifteen hours, the talc underwent inappreciable change of weight. Upon leaching, only 0·23 per cent of magnesia went into solution. By rapid evaporation with 75 cc. of fuming aqueous HCl, 1·05 per cent of MgO and 0·16 of $(FeAl)_2O_3$ were dissolved. Upon eight days' digestion on the water bath with acid of 1·12 sp. gr., 1·94 MgO and 0·23 of sesquioxides were removed. By digesting in like manner for thirty-two days, 3·94 MgO and 0·41 of sesquioxides were taken out. Talc, therefore, is, as should have been expected, remarkably stable in presence of hydrochloric acid, both aqueous and dry. This fact has a very important bearing upon the constitutional formula of the mineral.

In empirical composition the talc analyzed agrees quite sharply with the accepted formula $Mg_3H_2Si_4O_{12}$. This is commonly interpreted as an acid metasilicate, $Mg_3H_2(SiO_3)_4$; but Groth has lately proposed to consider talc as a basic salt of pyrosilicic acid, $H_2Si_2O_5$. On this supposition its rational formula becomes $Mg(Si_2O_5)_2(MgOH)_2$. Between these two formulæ, experiment is able to decide.

Against Groth's formula the stability of talc towards acids tells very strongly. The univalent group $-Mg-OH$ ought to be soluble in hydrochloric acid; and evidence, to be presented later, goes to show that that particular group is easily removable by the dry, gaseous HCl. In fact, our experiments make it highly probable that all the magnesia taken from a silicate by perfectly dry HCl, was originally present in the hydroxylated form. As regards the constitution of talc, however, other evidence is even stronger.

If Groth's formula is correct, then, upon ignition, talc should behave according to the equation

$$Mg<\begin{matrix}Si_2O_5-Mg-OH\\Si_2O_5-Mg-OH\end{matrix}-H_2O=Mg<\begin{matrix}Si_2O_5-Mg\\Si_2O_5-Mg\end{matrix}>O.$$

In other words the loss of water should produce but little change, and no silica should be liberated. If, on the other hand, the acid metasilicate formula is true, talc should split up into $3MgSiO_3+SiO_2+H_2O$; that is, one-fourth of the silica should be set free; which, in the present instance, would amount to 15·57 per cent. This actually happens; and a weighed quantity of talc, ignited very intensely for half an hour over a blast-lamp, gave up 15·36 per cent of SiO_2 upon subsequent boiling with a solution of sodium carbonate. Upon longer ignition, as might be expected, a part of this silica reverts to the insoluble form, and somewhat lower results are obtained. Upon the unignited talc, boiling with soda solution for twenty-four hours produced little or no effect; soda was not taken up, nor was silica removed.

In brief, both lines of evidence, the liberation of silica and the stability toward acids, confirm the ordinary formula for talc and controvert the views of Groth; and no other formula out of several which are possible, satisfies both of the experimentally established conditions. The mineral, therefore, must be regarded as an acid metasilicate; although its ultimate structural formula can be written only when we have a better knowledge of metasilicic acid. It is a noteworthy fact, that no normal metasilicic ether is yet certainly known; for Ebelmen's results have not been confirmed by later observers. Troost and Hautefeuille, however, prepared an ether having the composition $(C_2H_5)_8Si_4O_{12}$. Possibly enstatite may be the normal magnesium salt corresponding to this ether; in which case talc would be a substitution derivative having H_2 in place of one atom of Mg.

3. *Serpentine.*

On account of the importance of this species, its variability in external characteristics, and its manifold relations to other minerals, several distinct samples were investigated.

A. Dull-green serpentine from Montville, New Jersey, derived from pyroxene by alteration.

B. Dark-green serpentine from the well-known locality at Newburyport, Massachusetts.

C. Silky, fibrous chrysotile from Montville.

D. Grayish-green picrolite from Buck Creek, North Carolina.

E. A grayish green mineral from Corundum Hill, North Carolina, which was supposed at first to be deweylite. It is an ordinary, massive serpentine.

Analyses as follows, with the itemized water determinations subjoined.

	A	B	C	D	E
SiO_2	42·05	41·47	42·42	42·94	41·90
H_2O	14·66	15·06	15·64	13·21	16·16
MgO	42·57	41·70	41·01	36·53	40·16
FeO	·10	·09	undet.	1·88	undet.
CaO	·05	none	trace	----	----
NiO	----	----	·23	·61	·10
Fe_2O_3	·30	1·73	·62	3·33	·91
Al_2O_3	----		·63	1·72	·71
	99·73	100·05	100·55	100·22	99·94

H_2O at 105°	·96	1·20	2·04	1·53	2·26
H_2O at 250°	·55	·55	·71	·44	1·01
H_2O at 383°–412°	·27	----	·27	·62	·98
H_2O at 498°–527°	·23	----	·56	----	·42
H_2O at red heat	12·37	13·01	11·81	10·58	11·32
H_2O at white heat	·28	·30	·25	·04	·17

From these data it is clear that practically all the water in serpentine is constitutional, and that none of it can be fairly regarded as crystalline. The small, variable amount lost below 250° is mainly hygroscopic and enclosed water, since the analyses refer to air-dried material. It is hardly necessary to state that in each fractional determination the material was heated to constant weight.

Upon heating in dry, gaseous, hydrochloric acid all of these serpentines were strongly attacked; differing essentially in this particular from olivine and talc. The bases thus taken out as chlorides at 383°–412° were as follows:

	A	B	C	D	E
No. of hours heated	54	68	54	78	41
MgO extracted	10·14	16·73	9·98	11·38	15·25
R_2O_3 extracted	----	·43	----	·66	·51

In the last determination the soluble magnesia was accidentally lost; and the value given was estimated by difference. A duplicate determination on the Newburyport mineral, at the same temperature, with 39 hours' heating gave only 14·43 per cent of magnesia removed as chloride. The different times required for obtaining constant weight and so fixing the limit of the reaction vary considerably.

Similar experiments upon serpentines A and B at the temperature 498°–527° gave similar results.

	A	B
Hours heated.....	18	18
MgO removed.....	10·83	14·28
R_2O_3 removed.....	·10	·16

In duplicate determinations at the same temperature, A yielded 14·17 and B gave 17·36 per cent of magnesia converted into chloride.

Now these data, although not satisfactorily concordant, have nevertheless some significance. They show first that the action of the gas is much the same at both of the temperature intervals, except that the limit of change is reached more quickly in the hotter series. They show, also, that the magnesia of serpentine is probably combined in two ways; one part being affected, the other unattacked by the acid. That part which is converted into chloride, and so rendered soluble, we may regard provisionally as represented by the group —Mg—OH; even though our estimate of its amount may not be so sharply accurate as might be desirable. No other hypothesis as to the nature of the dissolved magnesia seems to be practicable, or to account in any way for the results of the experiments. Roughly speaking, a maximum amount of *about* one-third of the magnesia in serpentine is extracted by dry HCl under the conditions of our experiments, the other two-thirds being more stable.

By aqueous hydrochloric acid all of the five serpentines were easily and completely decomposed. In three instances this fact was determined quantitatively; by evaporating the acid to dryness with the mineral, extracting with weak acid, and weighing the residue. In each case this residue agreed in percentage with the silica found by actual analysis. The data are as follows:

	A	C	D
Insoluble in HCl	42·32	42·21	42·55
Silica found	42·05	42·42	42·94

By very weak hydrochloric acid, however, these three serpentines are but partially decomposed; the picrolite being the

most stable of the series. A microscopic examination of the picrolite by Mr. Waldemar Lindgren showed no inclusions which could account for this difference in behavior, and it is probably due to merely mechanical conditions.

Upon boiling directly with sodium carbonate solution, none of the serpentines were attacked. By sharp ignition, however, a little silica was sometimes liberated; which, as in the case of the talc, could be dissolved out and estimated. The quantities of silica thus set free were as follows:

	A	B	C	D	E
Per cent	6·23	2·00	2·98	none	6·05
	6·34	2·63			4·93

These results cannot easily be interpreted. At most, only about one seventh of the total silica is thus taken out; and this may represent either impurities in the minerals or secondary reactions of an undetermined kind.

When serpentine is heated to the point of fusion it is split up, as Daubrée has shown,* into a mixture of olivine and enstatite.

$$H_4Mg_2Si_2O_9 = 2H_2O + Mg_2SiO_4 + MgSiO_3.$$

Upon ordinary ignition, however, this breaking up of the molecule does not always take place; and when it does occur, it is as a rule only partial. In three experiments the serpentines A, C, and D, were strongly ignited over a blast lamp for an hour each, and then treated with strong hydrochloric acid. By this treatment, olivine, if formed, should be decomposed; while enstatite would remain unattacked in the residue. After evaporation to dryness and extraction with weak acid, the insoluble material was boiled with sodium carbonate solution to remove free silica, washed, dried, and weighed. The residues were as follows:

	A	C	D
Per cent	4·32	20·80	39·96

The residue from the massive Montville serpentine contained 43·28, and that from the chrysotile 41·34 per cent of magnesia, thus agreeing nearly with enstatite in composition. The picrolite residue was composed of—

MgO	36·31
SiO_2	54·88
R_2O_3	9·26
	100·45

* Compt. Rend., lxii, 661, 1866.

showing it to be an impure enstatite, the impurities being analogous to those of the original mineral. In the last case the splitting up seems to have been practically complete; in the chrysotile it went fully half way, while in the ordinary serpentine it barely began. The conclusion is obvious. When serpentine is simply dehydrated, the molecule $Mg_3Si_2O_7$, decomposable by acids, remains; and this on further heating splits up in accordance with Duabrée's observations. The salt Mg_2SiO_4 corresponds to certain well-known silicic ethers, and is probably a definite compound.

Now, bearing upon the constitution of serpentine, we have several lines of evidence. First, its empirical formula, $H_4Mg_3Si_2O_9$ is well-known, and in this all the water is constitutional. Second, upon dehydration it yields the salt $Mg_3Si_2O_7$. Third, a part of the magnesia is less stably combined than the remainder of the base, and is presumably present as —Mg—OH. If one atom of magnesium, or one-third of the total, is thus combined, the excess of one atom of oxygen over the normal orthosilicate ratio in the formula is accounted for, and the conditions imposed by our experimental results are satisfied.

Taking all these considerations into view it seems highly probable that the constitutional formula of serpentine may be written $Mg_2(SiO_4)_2H_2(MgOH)$. In ultimate structural form this may be interpreted in several ways, any one of which will admit of a linking together of the two orthosilicic groups, after dehydration, with elimination of one oxygen atom, to form the acid group Si_2O_7. Between the several possible structures, however, we are not as yet prepared to decide, and further investigation covering other hydro-magnesia silicates is necessary. Bearing in mind the very common derivation of serpentine from olivine, and the obvious relations of both species to chondrodite, the following formulæ are highly suggestive; the first one representing olivine with double its simplest expression:

$Mg_4Si_2O_8$	Olivine.
$Mg_3Si_2O_6(MgF)_2$	Chondrodite.
$Mg_2Si_2O_8H_2(MgOH)$	Serpentine.

In the chondrodite formula of course, the group –Mg–O–Mg– to a certain extent replaces the two univalent MgF groups. Although these formulæ are not absolutely proven, they are at least highly probable; and they conform perfectly to the general working hypothesis that the more complex silicates are substitution derivatives of normal salts.

One other formula for serpentine, $MgSi_2O_7(MgOH)_2H_2$, is reconcilable in part with our data. But such a compound ought to be acted upon more strongly by gaseous hydrochloric acid, and two-thirds of the magnesia should be removable. This limit was not even remotely approached in our experiments, although in two cases the one-third limit was definitely exceeded. It is a legitimate question, however, whether there may not be two isomeric serpentine molecules, corresponding to these two formulæ; and this question ought to be kept in view in future investigations.

[To be continued]

ART. XLII.—*On five new American Meteorites;* by GEORGE F. KUNZ.

1. *On the group of Meteorites recently discovered in Brenham Township, Kiowa County, Kansas.*

ABOUT four years ago, the farmers of Brenham Township ploughed up a number of heavy objects, which they used to weight down haystacks and for other like purposes, as they would have used boulders. It was discovered in March last that these were not common "rocks," but an interesting group of meteorites, numbering over twenty in all, weighing together about 2,000 pounds, and individually from 466 pounds down to one ounce. They were found imbedded at a slight depth in the soil, which here, for about one hundred feet deep is formed of Pleistocene marl, originally the bottom of an ancient lake; they occurred scattered over a surface more than a mile in length, principally, however, in a square of about sixty acres.

What is now Kiowa County, Kansas, five years ago formed parts of Edwards and Comanche counties, and was occupied by large ranges and cattle ranches. Brenham Township, or Township 27, as it was then called, is in the northwestern part of Kiowa County, consists of high prairie with some areas of sand-hills, and has an altitude of about 220 feet above sea-level. Some drains of the head-waters of the Medicine River and its tributaries, farther south, become ravines and valleys; and there a gravel occurs, the debris of Miocene "Loup Fork" conglomerates. But on the high prairie not a stone of any kind is to be found; hence the ranchmen and settlers were greatly surprised at finding heavy "rocks" or stones projecting through the prairie sod.

Several years ago, Mr. Davis, a lawyer at Greensburg, identified these as meteorites; and although the farmers had thus

known the fact for a long time, yet, strange to say, no importance was attached to them until Mrs. Kimberly applied to Professor F. W. Cragin, of Washburn University, in the early part of last spring. It was not until the 13th of March that Professor Cragin secured four of these masses. They were nearly all found by being struck by mowing-machines, ploughshares, corn-cultivators, or other farm implements. Over twenty distinct masses have been reported; but it is very evident, from the weight and other facts, that some have been noted several times over. The townships are reckoned from the base-line, the 40th parallel; and the ranges, from the 6th principal meridian, which crosses Kansas about longitude 97° 30′ west of Greenwich. Brenham Township [27] is made up of thirty-six sections, each one mile square, numbering from No. 1 to No. 36. The meteorites seem to have covered an area over one mile in length. Some of them fell on the east half of the northwest quarter, Section 27, Township 28, Range 17, west of the 6th principal meridian.

The history of some of the pieces is remarkable. The 35·72-pound piece, found on the Evans place, was lost, and again found in a hole made by hogs under a barbed-wire fence. The 75-pound mass was used by Mrs. Kimberly to hold down a cellar door or the cover to a rain-barrel. Mass No. 3 was used to keep down a stable-roof. The 466-pound mass [called by the farmers the "moon meteorite"] was covered by only three inches of soil, and broke a ploughshare when first struck. Apparently none of the masses were buried to a greater depth than five or six inches.

The 101·5-pound, the 71·5 pound, and the 55-pound masses were found four years ago by a cow-boy, when the ranch had not yet been occupied by settlers, being simply used as a cattle-range. He was unable to move them to the "Green's Stage Station," now Greensburg, eight miles distant, and so buried them in the gulch a mile northwest of the Kimberly farm on the "Francisco Claim." About a year afterward he became ill, and died; but before his death he communicated the burial of the "three strange rocks," as he called them, to two of the settlers, who succeeded in finding them and bringing them to the new town of Greensburg about a year later. The 55-pound mass was carried over by a neighbor, who used it to weight down his haystack.

Professor Snow, of Lawrence, Kansas, visited Kiowa County several times, and the last time obtained the 101·5-pound mass in the streets of Greensburg, the county seat, where it had lain for several years in front of a lawyer's real estate office.

The exterior of all the masses shows the characteristic pitting. The surfaces have all been more or less oxidized by

exposure to the elements, showing that the fall is not recent, and that the original mass was made of crystalline iron as well as of iron filled with crystals of olivine; in other words, the masses show two distinct groups. Of these, the 345-pound and the 75-pound ones are nickeliferous iron of highly octahedral structure and cleavage, and are caillites, while the others are meteoric iron containing olivine, and belong to the group known as pallasites.

The largest mass, a pallasite, weighs 466 pounds, or 211·818 kilos. It is thick, slightly flattened, triangular in form, somewhat heart-shaped, and measures through the longest part 61 centimeters, or 24⅛ inches; across the widest part 48 centimeters, or 19 inches; and in the thickest part, 37 centimeters, or 14½ inches. It is covered with large indentations measuring 10x6x3 centimeters. The coating is more or less oxidized, but the olivine is perceptible in all parts of the mass. The dimensions of the 345 pound mass [158·818 kilos] are 60x37x29 centimeters, or 23¾x14½x11½ inches. It is slightly arch-shaped, is an iron with many pittings, and shows the characteristic magnetic oxide of iron crust. The 219-pound mass [99·535 kilos] measures 51x41x26 centimeters [20½x16½x10½ inches; in form like a three-sided pyramid. The 211-pound mass [95·909 kilos] is somewhat rounded, with a circular depression on one side.

There are two masses weighing 125 pounds [58·863 kilos] and 54·96 pounds [25·084 kilos] respectively. The 101·5-pound mass [46·136 kilos] is almost round, measuring 35x26x27 centimeters [13¾x10¼x10¾ inches]. The exterior is evenly pitted, and the center of each pitting is occupied by an olivine crystal. The 75-pound one [34·09 kilos] is an iron, and measures 32x22½x15 centimetres [12½x8½x5⅞ inches], in shape like a pear or ham covered with pittings. The crust has been changed somewhat by weathering. The 71·5 pound mass [32·485 kilos] measures 27x23x22 centimeters [10½x9x8⅝ inches]. It is a jagged, irregular square, and shows olivine crystals all over the exterior. The 60-pound mass [27·272 kilos] measures 36x21x17 centimeters [14⅛x8x6⅝ inches]. It is an elongated, rounded piece, with one large flat side showing large spaces filled with olivine. The 40-pound [18·181 kilos] measures 22x21x13 centimeters [8⅝x8⅛x5⅛ inches], of irregular shape, with one large projecting point. The 36-pound mass [16·363 kilos] measures 22x22x16 centimeters [8½x8½x6¼ inches. It is a flattened spheroid, containing some olivine, but almost entirely iron, showing large pittings like the 75-pound or the 345-pound masses.

There are seventeen or eighteen small masses weighing 18, 12, 7, 6, 5, 3 and 1 pounds respectively, and a few weighing only one ounce each. The 211 and 6 pound masses belong to

the University of Minnesota; the 125-pound mass, to Harvard University; the 101·5 to Yale University: the 218½ and the 54·96-pound masses, to the University of Kansas; the others are in the collection of the writer.

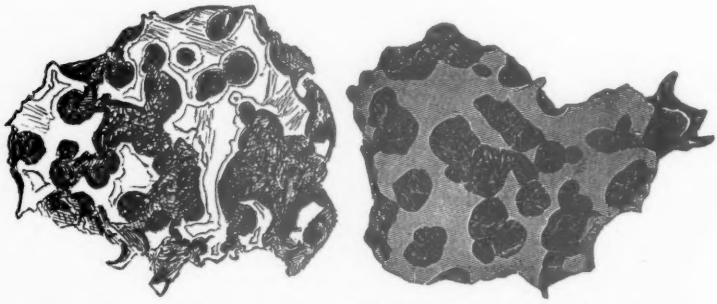
The specific gravity of the pieces is very variable, and was found to be as follows:—of the 6-pound mass, 5·17; 40-pound mass, 6·41; 71·5-pound mass, 5·22; 75-pound mass, 7·27; 345-pound mass, about the same density as the last; 466-pound mass, about the same density as the 71·5-pound mass. The following analyses of the Kiowa meteorites were made by Mr. L. G. Eakins in the laboratory of the United States Geological Survey:

Iron.		Olivine.		Dark Outer Zone of Olivine.	
Fe	88·49	SiO_2	40·70	SiO_2	34·14
Ni	10·35	Al_2O_3	tr	FeO	23·20
Co	·57	Fe_2O_3	·18	NiO	tr
Cu	·03	FeO	10.79	CoO	·03
P	·14	NiO	·02	MnO	·09
S	·08	MnO	·14	MgO	40·19
C	tr	MgO	48·02	S	5·42
Si	tr		99·85		103·07
	99·66			Less O for S	2·71
					100·36

The specific gravity of the iron freed from olivine was found to be 7·93 at 23·4° Celsius; of the olivine, 3·376 at 23·2°. The iron is brilliant white, enclosing the troilite, and surrounding the olivine crystals. Occasionally small etched surfaces show delicate figures like that of the Linnville Mountain meteorite. Troilite exists plentifully, in rounded grains from one to five millimeters in diameter, and in thin folia mixed with and surrounding the olivine crystals, as well as running into and filling small spaces in the body of the iron, either as flat plates or rounded masses. Several flat circular plates [crystals?] of graphite, two millimeters in diameter, were observed.

The olivine crystals are very brilliant, and break out entire, the faces on many of them being distinct enough to allow of measurement of the angles. The spaces from which they break are highly polished, showing every crystal face with a mirror-like luster; and in the center there is a coating of a shining mineral that is jet-black in color, and crushes into a jet-black powder. Many of the olivine crystals are in two distinct zones,—the inner half a bright transparent yellow, the outer a dark-brown iron-olivine. In reality this dark zone is an intimate mixture of troilite and olivine, as the analysis of

Mr. Eakins and a microscopical examination of the crystals by Mr. J. S. Diller, of the United States Geological Survey, fully prove.



This group of meteorites, which has recently come to me for description, possesses more than ordinary interest, on account both of the peculiar composition and structure and also of the undoubted ethnological relation, especially because of its probable connection with the meteoric iron found in the Turner mounds.

In the spring of 1883, Professor F. W. Putnam found on the altar of mound No. 3 of the Turner group of mounds, in the Little Miami Valley, Ohio, several ear-ornaments made of iron, and several others overlaid with iron. With these were also found a number of separate pieces that were thought to be iron. They were covered with cinders, charcoal, pearls [two bushels were found in this group of mounds], and other material, cemented by an oxide of iron, showing that the whole had been subjected to a high temperature. On removing the scale, Dr. Kennicutt found that they were made of iron of meteoric origin.* One of the pieces weighed 28 and the other 52 grains.

In the autumn of 1883, a mass was found on the altar of mound No. 4 of this same group, which weighed 767·5 grams [27·25 ounces]. Dr. Kennicutt suggested that these were all parts of some larger meteoric mass. The results of the investigation were published in connection with the description of the Atacama meteorites, because in structure they approach more closely to the latter than to those of any other occurrence known at that time. In the Liberty group of mounds in the same valley, Professor Putnam found a celt five inches long, and in another of the Turner mounds an ornament five inches long and three inches wide, made also of the same meteoric iron.

* Sixteenth and seventeenth reports of the Peabody Museum of Archæology, p. 382.

The Carroll County meteorite was found in 1880, about three-quarters of a mile from Eagle Station, Carroll County, Kentucky, ten miles from the mouth of the Kentucky River, and about seven miles in a direct line from both the Kentucky and the Ohio Rivers. The distance to the Turner mounds, where Professor Putnam found the meteoric iron and the ornaments made of it, is about sixty miles. The mass, which weighed about eighty pounds, or 36·5 kilos, was rusted on the surface to a depth, in some places, of 10 to 12 millimeters; and deep pits, some two centimeters across, are observed in the spots where grains of olivine have probably dropped out. The meteorite was largely made up of fine yellow transparent olivine resembling that of the famous Pallas iron, with a specific gravity of 4·72.

Taking the specific gravity of the iron at 7 6, and that of the olivine at 3·3, we find that the Turner mound meteorites consist of about three parts of olivine to one of iron. Several of the Kiowa masses have about the same constitution. For comparison, see the analyses of the Kiowa meteorites, given above, and of the olivine and iron from the Turner mound,* here inserted, as follows:

Olivine.		Iron.	
SiO_2	40·02	Fe	89·00
FeO	14.06	Ni	10·65
MnO	0·10	Co	0·45
MgO	45·60	Cu	tr
	99·78		100·10

When the Carroll County iron was described by the author in this Journal (vol. xxxiii, March, 1887), it was suggested that the pieces found by Professor Putnam in the Miami mounds had probably been taken from that mass, since no other olivine meteorite had up to that time been found in North America; while that of Carroll County contained a large percentage of olivine, even greater than the mound specimens. Very little cutting had been done on the Carroll County mass; and it proved on being cut, not to be a pallasite, but a brahinite variety of meteorite. In the Little Miami valley meteorite are embedded circular grains or crystals of olivine; whereas that of the Carroll County consists of a mass of olivine in which the iron serves as a filling between the crystals. When a section was cut from the Kiowa County material, however, there appeared no doubt as to the identity of this fall with that from which the ear-rings were made that were found in the mound. In both the Kiowa County and

* Kennicutt; 16th and 17th Reports of the Peabody Museum of Archæology, p. 382.

the mound specimens the body of the meteorite is iron, in which are imbedded circular masses or crystals of olivine. The fact that in connection with the large Kiowa masses a number of small portions, weighing from half a pound to six pounds each, were found, makes it very probable that a small mass, of perhaps three or four pounds, had been conveyed by the Indians to the Ohio valley. Probably the two ear-rings in the collection of Mr. Warren K. Moorhead, recently found by him at Fort Ancient, Ohio, may have been made from a part of the mass weighing 767·5 grams, which is now in the Harvard University collection.

I must here express my indebtedness to Professor F. H. Snow for information, and particularly to Professor Robert Hay for aiding me in procuring many of the meteorites and assisting greatly to obtain exact data by visiting the place of discovery, and to secure the illustrations; as also to Mr. L. G. Eakins for making the analyses, and to Professor F. W. Clarke, of the U. S. Geological Survey, for his courtesy in having them made at the Survey Laboratory.

2. *On the Winnebago County, Iowa, Meteorite.**

On Friday, May 2, 1890, at 5.15 P. M., standard Western time, a meteor was observed over a good part of the State of Iowa. It is described as a bright ball of fire, moving from west to east, leaving a trail of smoke which was visible for from ten to fifteen minutes; it was accompanied by a noise, likened to that of heavy cannonading or of thunder, and many people rushed to their doors, thinking it was the rumbling of an earthquake. Substantiated reports have been received from DesMoines, Mason City, Fort Dodge, Emmetsburg, Algonia, Ruthven, Humboldt, Britt, Garnet, Grinnell, Sioux City and Forest City; the noise was also heard at Chamberlain, South Dakota. Some of these places were distant more than a hundred miles from the point where the meteor fell. It exploded about eleven miles northwest of Forest City, at Leland, Winnebago County, in the center of the northern part of Iowa, latitude 43° 15′, longitude 93° 45′ west of Greenwich, near the Minnesota State line, and the fragments were scattered over an area one mile wide and nearly two miles long. Up to the present time, there have been found masses weighing respectively eighty pounds, sixty-six pounds and ten pounds, two of four pounds and about five hundred fragments weighing from one-twentieth of an ounce to twenty ounces each, while a part of the mass is believed to have passed over into Minnesota. The pieces are all angular, with rounded edges.

* Read before the New York Academy of Sciences, May 12, 1890.

The meteorite is a typical chondrite, apparently of the type of the Parnallite group of Meunier, which fell February 28, 1857, at Parnallee, India. The stone is porous, and when it is placed in water to ascertain its specific gravity, there is a considerable ebullition of air. The specific gravity, on a fifteen-gram piece, was found to be 3·638. The crust is rather thin, opaque black, not shining, and, under the microscope, is very scorious, resembling the Knyahinya, Hungary, and the West Liberty, Iowa, meteoric stones. A broken surface shows the interior color to be gray, spotted with brown, black and white, containing small specks of meteoric iron, from one to two millimeters across. Troilite is also present in small rounded masses of about the same size. On one broken surface was a very thin scum of black substance, evidently graphite, soft enough to mark white paper; a feldspar (anorthite) was likewise observed, and enstatite was also present.

Results and analyses furnished by L. G. Eakins.

Approximate composition of the mass.		Analysis of the Nickeliferous Iron.	
Nickeliferous iron	19·40	Fe	92·65
Troilite	6·19	Ni	6·11
Silicates soluble in HCl	36·04	Co	·65
Silicates insoluble in HCl	38·37	P	tr
			99·41

Specific gravity of the mass, 3·804 at 28·5° Celsius.

Analysis of the siliceous portion, with the magnetic extracted.

Soluble in HCl. (1.)		Calc. to 100 p. c. (2.)	(3.)	Insoluble in HCl. (4.)	Calc. to 100 p. c. (5.)
SiO_2 17·82		17·82	39·74	SiO_2 26·49	55·51
				Al_2O_3 2·59	5·43
FeO 14·27	6·01 FeO, equiv. to 4·67 Fe, required by S to form FeS	8·26	18·42	Cr_2O_3 ·12	·25
				FeO 4·49	9·45
NiO ·17		·17	·38	NiO tr	
MnO tr		tr		CaO 1·45	3·00
CaO ·31		·31	·69	MgO 11·50	24.09
MgO 18·28		18·28	40·77	K_2O ·07	·15
Alkalies tr		tr		Na_2O 1·01	2.12
S 2·67	[2·678 to form FeS]			47·72	100·00
P_2O_5 tr		tr			
53·52		44·84	100·00		
O for S 1·34					
52·18					

The approximate composition of the mass was got by extracting everything possible by an electro-magnet, which took out all the nickel iron and a little troilite, leaving the siliceous part and most of the troilite. Then the amount of S present in the magnetic portion, and that in the siliceous portion, was calculated as FeS; the silicates were split into two portions by

HCl, and by the weights found in each case, the given approximate composition was calculated. Under the head of analysis of nickeliferous iron is given the analysis of the metallic portion after allowing for a very slight amount of attached silicates and troilite.

The analyses numbered from 1 to 5 are the residue left after removing all the magnetic material. Column 1 is the part soluble in HCl, column 4 that insoluble in HCl; these two added together would give the analysis as a whole of the non-magnetic portion. Column 2 is the same analysis as 1, after removing the 2·67 per cent S and an amount [6·01 per cent] of FeO equivalent to the Fe necessary to form troilite with the S. Column 3 is the same as 2 calculated to 100 per cent. Column 4, as stated, is the analysis of the insoluble portion, and 5 is the same to 100 per cent. It is of course probable that the Cr_2O_3 represents chromite, and possible that the alkalies and alumina with a little lime represent a soda-lime feldspar.

The thanks of the author are due to Mr. L. G. Eakins for the analysis and results furnished, and to Professor F. W. Clarke for his courtesy and assistance by having the analyses made in the U. S. Geological Survey Laboratory.

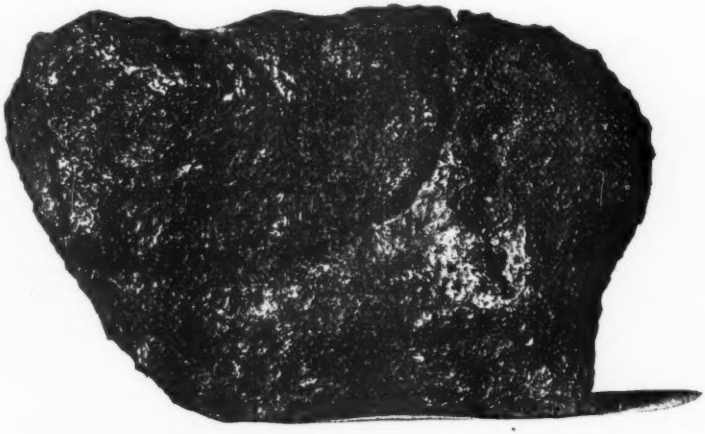
3. *On the Meteoric Stone from Ferguson, Haywood County, North Carolina.*

Mr. W. A. Harrison, of Ferguson, Haywood County, North Carolina, says: that about six o'clock on the evening of July 18, 1889, he noticed a remarkable noise west of him, and that fifteen minutes later he saw something strike the earth, which, on examination, proved to be a meteoric stone, so hot that he could scarcely hold it in his hand five minutes after it fell. Two-thirds of its bulk was buried in the earth when found. This stone was sent to the writer and was unfortunately lost in New York city during the month of December. The stone was slightly oblong, covered with a deep, black crust, which had been broken at one end, showing a great chondritic structure with occasional specks of iron. Its weight was about eight ounces: and it very closely resembled the meteoric stone from Mocs, Transylvania. It remained in the writer's possession so short a time that it was not properly investigated, but still the mere mention of a fall which had been so carefully observed is thought to be well worthy of publication.

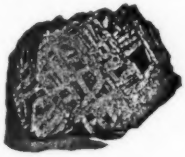
4. *Meteoric Iron from Bridgewater, Burke County, North Carolina.*

The Bridgewater, Burke County, meteorite was found by a negro plowman, two miles from Bridgewater Station, in the

western part of Burke County, near the McDowell County line in North Carolina, latitude 35° 41′, longitude 81° 45′ west of Greenwich. The negro thought that it must be either gold or silver, from its weight, and took it to some railroad laborers, who broke it in two pieces, one of which weighs ten and a half pounds, and the other eighteen and a half pounds, together 30 pounds, equal to 13·63 kilos. It measures 22½x15 x10 cm. [9x6x4 inches.] [See fig. 1].



Traces of black crust very much oxidized are still visible on the surface. The iron is highly octahedral in structure, and the mass was readily broken by the laborers who found it. Between the cleavage plates schreibersite is visible. On etching a polished surface of this iron with dilute nitric acid, the characteristic Widmanstätten figures were shown, (see fig. 2). The iron belongs to the caillite group and resembles those of the Cabin Creek and Glorietta Mountain in structure. The specific gravity of a fragment was found to be 6·617. The following analysis was kindly furnished by Professor F. P. Venable of the University of North Carolina.



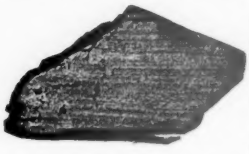
Fe	88·90
Ni	9·94
Co	·76
P	·35
Cl	·02
	99·97

The nickel is the mean of two determinations, 9·74 and 10·14, on different parts of the sample; the cobalt also of two determinations, ·85 and ·67. The iron is the mean of four determinations, some of which were not very closely agreeing, as the crust could not be entirely removed from the samples taken. The phosphorus and chlorine are single determinations. The author takes great pleasure in thanking Mr. T. K. Brunner for his courtesy in obtaining the information and the iron for him, and also Professor F. P. Venable for furnishing the analysis.

5. *Meteoric Iron from Summit, Blount County, Alabama.**

This mass of meteoric iron was found near Summit, Blount County, Alabama, latitude 33° 41′, longitude 86° 25′ west of Greenwich, in Fraction A, Section 2, Township 10, Range 1, east, by a six-year-old negro girl who used it to crack hickory nuts. Its great weight excited some curiosity, and her brother sent it to Mr. St. John, of Summit, and through the courtesy of Professor Eugene A. Smith it passed into the possession of the writer. It measures 12·5x5x7·5 centimeters [5x2x3 inches] and weighs one kilogram [2 2 pounds].

This meteorite contains a large quantity of free chloride of iron [Lawrencite] which from time to time has formed in beads on the surface. It showed only a slight trace of the original crust and was almost completely oxidized; and on etching a polished surface of this iron with nitric acid no Widmanstätten figures were developed, but instead a fine marking similar to that of the Linnville Mountain, N. C., meteorite. The specific gravity of a fragment was 6·949. The following analysis was kindly given by Professor F. P. Venable of the University of North Carolina:



* Trans. N. Y. Acad. Sciences, Jan. 27, 1890.

Fe	93·39
Ni	5·62
Co	·58
P	·31
	99·90

The iron is the mean of three fairly agreeing determinations, the nickel of two determinations, 5·61 and 5·63, the cobalt of two determinations, and the phosphorus is a single determination.

We take great pleasure in thanking Professor Eugene A. Smith for his assistance in obtaining the iron, and Professor F. P. Venable for furnishing the analysis.

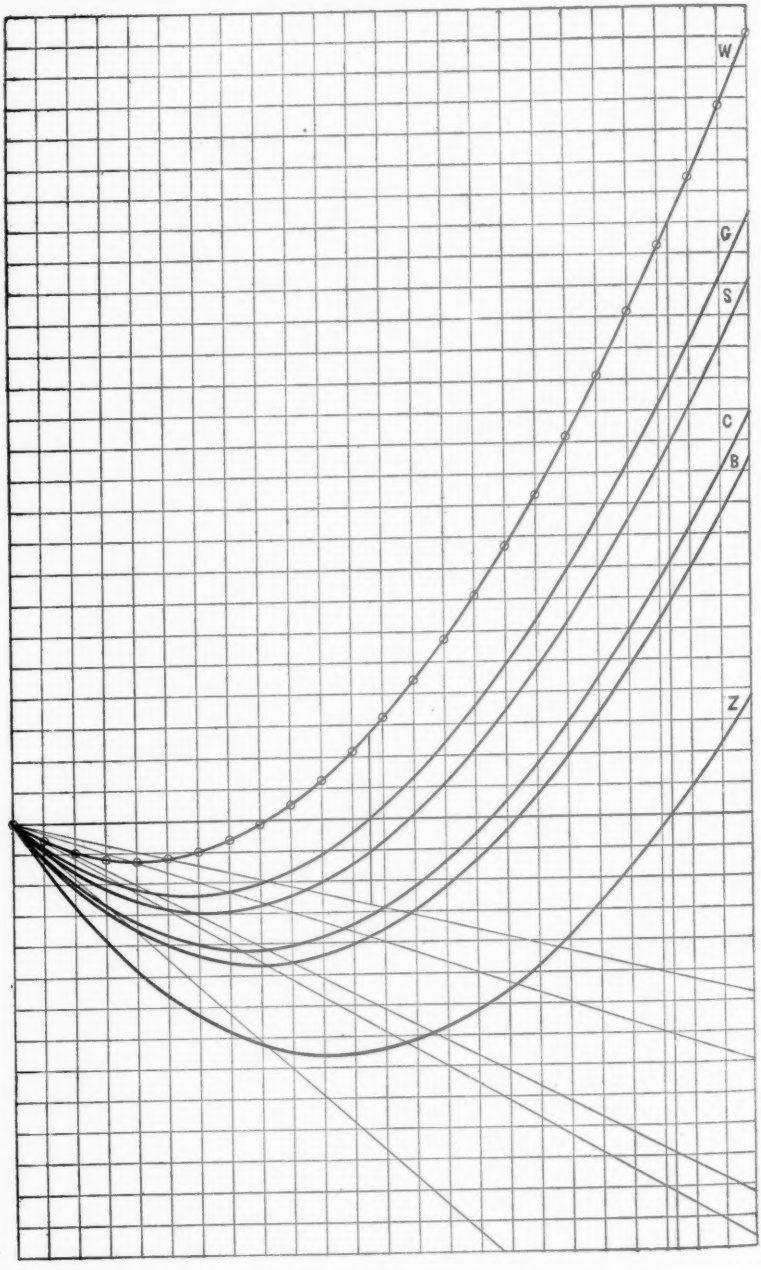
ART. XLIII.—*On the determination of the coefficient of cubical expansion of a solid from the observation of the temperature at which water, in a vessel made of this solid, has the same apparent volume as it has at 0° C.; and on the coefficient of cubical expansion of a substance determined by means of a hydrometer made of this substance;* by ALFRED M. MAYER.

[Read before the National Academy of Sciences, at Washington, April 21, 1886.]

The curve W of Fig. 1 shows the absolute expansion of water. The unit of abscissæ of this and the other curves is 1° C., the unit of ordinates is $\frac{1}{10000}$ of the unit of volume of the water, this unit of volume being at 0° C. The curve G shows the apparent expansion of water in a glass vessel, and curves S, C, B and Z are the respective curves of the apparent expansion of water in steel, copper, brass and zinc vessels. The curve W cuts the axis of X at 8° 4 centigrade; G at 11°·7; S at 12°·8; C at 15°·3; B at 16°·3; Z at 21°·5. These points of intersection correspond to the following coefficients of cubical expansion; for G, ·000025; for S, ·000033; for C, ·00005; for B, ·000056; for Z, ·00009.

Let us consider the curve G. The curve goes below W because water contracts from 0° to 4°, and the glass vessel by expanding adds to this fall of the water. Beyond 4° the water expands more than the glass and at 11°·7 the expansion of the water from 0° to 11°·7 equals the expansion of the glass through the same range of temperature, and the curve G cuts the axis of X at 11°·7. Therefore, to obtain the cubical expansion of the glass, or of any other substance forming the vessel, we have merely to determine the temperature at which water has the same apparent volume that it has at 0° C., and

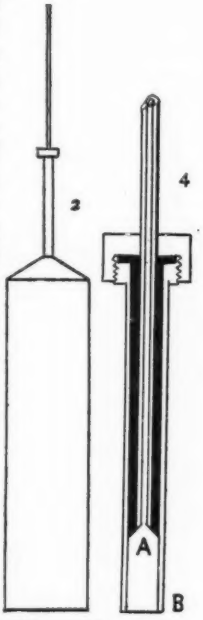
1.



at this temperature on the axis of X we measure the ordinate of the curve of the absolute expansion of water, and this ordinate gives in volume the expansion of the vessel in the determined range of temperature.

The second method of determining the coefficient of cubical expansion is that of floating a hydrometer, formed of the substance whose coefficient we would determine, in water at 0° C. and then gradually heating the water till the hydrometer floats to the same depth it did when the water was at 0° C'. Calling W the weight of the hydrometer, and V_0, D_0, V_t and D_t the respective volumes and densities of the water at 0° and $t°$, we have $V_0D_0=W$, and $V_tD_t=W$, and if V_0 and D_0 equal unity we have $V_t=1/D_t$, or, the volume at $t°$ is the reciprocal of the density at $t°$, which is the same as if we took V_t directly from the curve of the absolute expansion of water. Thus, by having the true curve of the absolute expansion of water, one may determine by either of the two methods just described, the coefficient of cubical expansion of a solid without measures of volume, of weight or of linear dimension.

We will now describe the apparatus used, give some measurements made with it and discuss the accuracy of the methods. Fig. 2 is the brass vessel used. It is a cylinder 25·4 cms. long and 6·147 cms. interior diameter. A glass tube ·203 cm. diameter of bore is connected with the interior of the cylinder as shown in Fig. 4. Into a brass tube shown black in the figure is cemented the glass tube. The lower opening of these tubes, A, is ground into a cone. The shoulder of this tube A rests on a thin leather washer on the top of the tube B. A screw-cap forces the tube A into close contact with B. This manner of attaching the glass tube to the cylinder was devised for convenience in our experiments, but the glass tubes may be directly cemented into the cylinder and thus do away with the inner tube and screw-cap.



The cylinder is nearly filled with distilled water and a rubber tube is led from the tube of the cylinder into a vessel holding boiling water. The water in the cylinder is boiled for a half hour and then the heat is withdrawn. As the steam condenses the vessel fills with water. The apparatus is allowed to cool down to the temperature of the room. The cylinder and glass tube is now surrounded with

ice, and when the level of the water in the tube has remained stationary for 15 minutes it is marked by pasting on the tube a piece of thin tracing paper on which is drawn in ink a very fine line. This line is made tangent to the meniscus of the water by the aid of a cathetometer. The ice is now replaced by cold water which is slowly heated. When the temperature had reached 8° C. the volume of water (in this special apparatus) had fallen 11 cms. below the level it had at 0°. It then slowly rose till at 15°·9 C. it reached the level it had at 0°. The temperature of the air of the room was above 15° 9. When the water was raised to 12° it was allowed, under constant agitation, slowly to reach 15°·9. To be sure that this was the temperature of the water inside the vessel the water outside was kept at this temperature by adding from time to time small portions of cold water. The water level remained the same for 10 minutes.

Referring to a curve of absolute expansion of water (drawn to the scale of 1 mm. = $\frac{1}{100000}$ of unit of volume) we find that the ordinate of 15°·9 is 1·000853, which is the cubical expansion of the brass caused by heating it from 0° to 15°·9, and ·000853 divided by 15°·9 gives ·00005364 the coefficient of cubical expansion of brass of the following composition: copper, 78·5 per cent; zinc, 21·05; lead, 0·25; tin, 0·15.

The delicacy of the method depends on the relative dimensions of the vessel and tube. In the apparatus just described the interior diameter of the vessel is 6·147 cms; its length 25·4 cms; the bore of the tube is ·203 in diameter; hence $\left(\frac{6{\cdot}147^2}{{\cdot}203^2} \times 25{\cdot}4\right) \div 1000 = 23{\cdot}589$, the length in cms. that the level of the water changes for a change of $\frac{1}{1000}$ in the volume of the cylinder, and a change of $\frac{1}{100000}$ of the volume equals ·023 cm., or ·23 mm., of motion of water in the tube. From the curves of apparent expansion of water in vessels of the following named materials we find that a change of 0°·10 in the water at the temperature when the water has the same apparent volume as at 0° equals a change of volume given opposite the respective materials forming the vessels as follows:

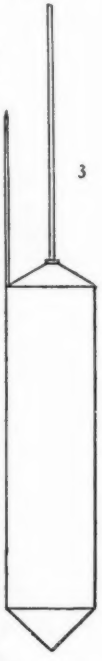
± 0°·1 C.	causes a	change of	apparent volumes of	·000008	in a glass vessel.
"	"	"	"	·000009	" steel "
"	"	"	"	·000010	" copper "
"	"	"	"	·000011	" brass "
"	"	"	"	·000013	" zinc "

From above data we compute that with a cylinder, or bulb, and tube of the same dimensions as those of the brass vessel and tube described,

± 0°·1 C.	causes a	motion of	1·84 mm.	in a similar vessel of glass.
"	"		2·07 "	" steel.
"	"		2·30 "	" copper.
"	"		2·53 "	" brass
"	"		2·99 "	" zinc.

The cathetometer readily detects and measures a motion of $\frac{1}{20}$ mm.; so it appears that a change of temperature of $\frac{1}{400}°$ causes a change in level of water in the tube which can observed. The thermometer, however, was read only to $\frac{1}{20}°$.

It remains to examine into the effect of the glass tube attached to the metallic vessel. This tube is necessary in order to observe the level of the water, but to get a rigorously correct observation the vessel and tube should be of the same substance. The effect of replacing the glass tube by a similar one of the same material as that of the vessel is readily calculated and is found to be a quantity that may be neglected. Thus in a brass tube 50 mm. long and 2·03 mm. in diameter the level of the water at the higher temperature of 16° will stand ·014 mm. lower than in a glass tube of the same dimensions, and at 21°·5 the water will be ·05 mm. lower in a zinc tube than in one of glass.



The coefficient of cubical expansion of glass was determined by means of a spherical vessel of 12 cm. diameter with a tube of 2·5 mm. interior diameter. The level of the water in this vessel was the same at 11°·75 and at 0°. The volume of water at 11°·75 is 1·0003 and $\frac{\cdot 0003}{11\cdot 75} = \cdot 0000255$ the coefficient of cubical expansion of this kind of glass. Kopp gives ·000024 and ·000026 as the coefficients for a similar soda glass.

The coefficient of expansion hydrometer was used to determine the coefficients of expansion of brass and of hard rubber, or ebonite. The hydrometer, fig. 3, was made of the same kind of brass as that forming the cylinder used in the determination of this coefficient. The cylinder of the hydrometer is 25·5 cm. long terminated by cones. Its diameter is 7·3 cm. The stem of the hydrometer is a brass tube of 2 mm. exterior diameter. The hydrometer of hard rubber is a cylinder 21·5 cm. long and 6·5 cm. in diameter with a stem 2 mm. in diameter. To float these hydrometers in water at 0° and at a higher temperature, a pointed rod, as shown in the figure, was used. This point, by just touching the surface of the water, showed the depth of flotage. These hydrometers were made to float in water at 0°, with their index-points just touching the surface of the water, by loading them with fine shot. The water was then slowly heated and it was found that the brass hydrometers floated to the same depth at 0° and at 15°·85, and the hard rubber hydrometer had the same depth of flotage at 0° and at 38°·55.

The volume of water at 15°·85 equals 1·060845, and $\cdot\frac{0\,0\,0\,8\,4\,5}{1\,5\cdot8\,5}$ = ·0000533, the coefficient of cubical expansion of the brass. The previous determination with the brass cylinder gave ·0000536.

The volume of water at 38°·55 is 1·00697, and $\cdot\frac{0\,0\,6\,9\,7}{3\,8\cdot5\,5}$ = ·0001808, the coefficient of expansion of hard rubber. Mercury has at 30° a coefficient of ·0001805. Hard rubber has the greatest coefficient of any solid. To show on the curve of apparent expansion of water in a vessel of hard rubber its points of intersection of the axis of x, on the scale of fig. 1, the axis of x would have to be extended $\frac{4}{10}$ of its present length.

These determinations with the hydrometer have the advantage of those made by observations on the volume of water contained in a vessel, because the metal of the hydrometer changes its temperature with that of the water, which is not the case with the vessel filled with water, whose temperature lags behind that of the outside water. This makes the observation on the upper temperature of the water in the vessel tedious and not precise unless the precautions are taken which we have already mentioned.

The accuracy of this method of determining the mean coefficient of expansion of water, in the determined range of temperature, depends on having the water in the vessel and the substance of the hydrometer at the same temperature as the water surrounding these bodies. This can be obtained to $\frac{1}{2\,0}$° C. In the case of a vessel filled with water we have already stated the precautions necessary. The hydrometer is floated in water at 0° by surrounding with ice a vessel holding water which has already been cooled to 0° and from which the floating ice has been removed.

The accuracy, however, of this method depends essentially on having the true curve of the absolute expansion of water between 0° and 30°. It is not possible to say to what approximation we have this true curve; but that it is quite close may be inferred from the following account of how Rossetti projected a curve which is the best we have at present.

Prof. F. Rossetti describes his experiments and the manner of obtaining the curve in the Atti dell' Instituto Veneto, vol. xiii, 3 series, 1868. Rosetti's new determination of the volume of water at various temperatures between −6° and 100° were made with every precaution to ensure accuracy. He then combines the results of his experiments in a curve projected according to the method of Schiapparelli.* He then combined his results, thus reduced, with those of Depretz (1839); Kopp

* Schiapparelli, Sul modo di ricavare la vera expressione dellé leggi della natura dalle curve empiriche; Nuovo Cimento, Tomo xxv, 1867; e Tomo xxvi, 1867.

(1847); Pierre (1845–52); Hagen (1855); and Matthiesen (1866). These six series of determinations were also combined by the method of Schiapparelli and the resultant curve Rossetti adopted as the most accurate attainable from existing data. From this curve, in which 1 mm. of ordinate equalled $\frac{1}{100000}$ of the volume of water at 0° C., he obtained the following formula which represents the curve quite closely.

$$V_t = 1 + a(t-4)^2 - b(t-4)^{2\cdot5} + c(t-4)^3$$

when

$a = \cdot00000837991$; $b = \cdot000000378702$; $c = \cdot0000000224329$.

From Rossetti's table of the relations of the volume, density and temperature of water we extract the following data which are all that will be required in their application to our method of determining the coefficient of cubical expansion.

Temp. C°.	Volume.	Temp. C°.	Volume.	Temp. C°.	Volume.
0	1·000000	14	1·000572	28	1·003553
1	·999943	15	1·000712	29	1·003835
2	·999902	16	1·000870	30	1·004123
3	·999880	17	1·001031	31	1·00442
4	·999871	18	1·001219	32	1·00473
5	·999881	19	1·001413	33	1·00505
6	·999901	20	1·001614	34	1·00538
7	·999938	21	1·001828	35	1·00572
8	·999985	22	1·002049	36	1·00608
9	1·000047	23	1·002276	37	1·00645
10	1·000124	24	1·002511	38	1·00682
11	1·000216	25	1·002759	39	1·00719
12	1·000322	26	1·003014	40	1·00757
13	1·000441	27	1·003278		

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SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *Steam Calorimeter.*—K. Wirtz has modified the steam calorimeter of Bunsen and Jolly and has shown how the method of these investigators can be employed to measure the latent heat of vapor of substances with low boiling points. A weighed amount, G, of the substance is vaporized in the steam of the calorimeter. Heat is withdrawn from the steam and a portion of the latter is condensed. Calling w the weight of the condensed steam, λ the latent heat of steam, the latent heat, Q, of the vapor of the substance between the temperature before it is put into the calorimeter and its boiling point will be $Q=\frac{w\lambda}{G}$. The author discusses the sources of error. The results obtained by him are in general smaller than those obtained by Regnault, Person and Andrews. This failure of agreement is attributed by the author to the use of impure substances by the previous

observers. As an illustration of the effect of impurity of substance he instances ethyl ether; distilling this substance over sodium a loss of only 0·7 of one per cent resulted, whereas there was a diminution of five per cent in the value of the latent heat. —*Ann. der Physik und Chemie*, No. 7, 1870, pp. 438–449. J. T.

2. *A Mountain Magnetometer.*—O. E. MEYER has adapted the method of observation employed by Kohlrausch with the variometer to a new instrument. Both the movable needle and the controlling magnet move in a vertical plane instead of in a horizontal one. The instrument is thus a species of dipping needle or a vertical variometer. The author finds it well adapted to observing the attraction of large masses of rock, and to noting changes in the magnetic field in various parts of observatories and laboratories caused by variations in the magnetic condition of the materials of which these buildings are constructed. Observations with this new instrument show that large variations frequently observed in buildings can be attributed as much to change of direction of the magnetic force as to change in total value. The instrument is constructed by W. Siedentopf, University Mechanic in Würzburg.—*Ann. der Physik und Chemie*, No. 7, 1890, pp. 489–504. J. T.

3. *Velocity of Transmisison of Electric Disturbances.*—Maxwell's theory of light demands that the velocity of transmission of electric disturbances along a wire should be equal to the velocity of light through the dielectric surrounding the wire. The velocity is thus determined by the surrounding dielectric in which the energy resides. Professor J. J. THOMSON has made a number of experiments upon this subject and finds that the velocity of electric disturbances along wires surrounded by air is 1·7 times the velocity along the wire surrounded by sulphur. Experiments showed also that the velocities along wires surrounded by air, paraffin and sulphur are approximately proportional to the reciprocals of the square roots of their specific inductive capacities. The velocity of propagation of a rapidly alternating current along an electrolyte surrounded by air was found not to differ much from the rate along a wire. Experiments with a vacuum tube fifty feet long and a revolving mirror showed that the velocity of discharge through the rarefied gas was comparable with the velocity of light. The experiments on the rate of propagation of electric disturbances lead one to regard the conductor as merely guiding the discharge, "the correlation between the ether and the conductor compelling the discharge to travel along the latter with the velocity of light." Professor Thomson then discusses the application of his observations to the theory of electric striæ in vacuum tubes.—*Phil. Mag.*, Aug. 1890, pp. 129–140. J. T.

4. *Phosphoro-photographs of the ultra red.*—E. LOMMEL has taken up anew the method of Becquerel of observing the solar spectrum in the ultra red by means of phosphorescent substances. The spectrum is received on a surface covered with Balmain's paint. A dry photographic plate is then laid upon the phosphor-

escent image and a photograph can be taken as far as wave-length $\lambda=950$. Photographs were taken both by the prism method and by Rowland's concave grating.—*Ann. der Physik und Chemie*, No. 8, 1890, p. 681. J. T.

5. *Photography of Oscillating Electric Sparks.*—This has been accomplished hitherto by a revolving mirror or a revolving lens which spreads out the image of the spark. Professor Boys employs six lenses placed on a brass disc, on different radii. The disc revolves at a high rate of speed. The spark is formed on one side of the disc and a photographic plate is placed upon the other side.—*Phil. Mag.*, Sept. 1870, pp. 248–260. J. T.

6. *Electrical Discharges in Magnetic Fields.*—The experiments of M. A. Witz upon the action of magnets on electrical discharges in Geissler tubes leads him to believe that this action is due to a variation in the capacity of the tubes. They become true condensers and their illumination is the result of an oscillatory discharge of the same order as that of a Leyden Jar, of which the period T is a function of the capacity C of the jar, and of the coefficient L of self-induction of the conductor of small resistance, $T=\pi\sqrt{CL}$. A variation of the capacity C would thus modify the vibratory state of the gas and would be the cause of the differences observed in the luminous phenomena in intense magnetic fields.—*Nature*, Aug. 14, 1890, p. 384. J. T.

7. *Molecular Theory of Induced Magnetism.*—Professor Ewing states in a summary to an article on this subject his conviction of the truth of the molecular theory of induced magnetism, which is Weber's theory in a modified form. Perhaps the most important conclusion drawn is this, "That magnetic hysteresis and the dissipation of energy which hysteresis involves are due to molecular instability resulting from the intermolecular magnetic actions, and are not due to anything in the nature of frictional resistance to the rotation of the molecular magnets."—*Phil. Mag.*, Sept. 1890, pp. 205–222. J. T.

8. *Note.*—Error in Maxwell, vol. ii, § 544. Corrected by a second fault so that final result is correct.—*Nature*, 35, p. 172, 1886.

9. *The Elements of Laboratory Work.* A course of natural science; by A. G. Earl, M.A., F.C.S. 177 pp. London, 1890 (Longmans, Green & Co.).—This is an introduction to work in the physical laboratory, dealing with the fundamental phenomena and laws. These are taken up in such a manner and order of sequence as to lead the student to a knowledge of the principles involved rather than the details of manipulation. Some of the chapters consider the measurement of quantity of matter, observations of change of position, of changes of temperature, of natural changes exhibited by all kinds of matter and by certain kinds of matter—the former bringing in the idea of gravitation, etc., the latter of electric and magnetic stress. Further, an investigation of various kinds of matter, observations leading to the theory of the ether, etc.

II. Geology and Mineralogy.

1. *Notes on the meeting of the Geological Society of America at Indianapolis.* (From a letter to one of the editors.)—The summer meeting of the Geological Society was held on Tuesday, Aug. 19, Vice-President Alexander Winchell, in the absence of Prof. Dana, taking the chair. Eight papers were read in the course of the three sessions of the day. Mr. W J McGee gave an account of the Appomatox formation in the Mississippi embayment. He admitted that the formation traced to the Mississippi, became identified with the Lagrange formation of Safford and was equivalent also with a part of the Orange sand of Hilgard. Dr. Safford, who was present, expressed his willingness to surrender the name Lagrange; but it was questioned by others whether the law of priority should not hold.

Prof. C. H. Hitchcock gave an account of the Redonda phosphate occurring on Redonda, one of the Leeward islands of the Caribbean sea—first described and analyzed by Prof. C. U. Shepard (American Journal of Science for 1869 and 1870), making it a hydrous iron-alumina phosphate. He stated that it overlies and penetrates irregularly a basic lava, and is interstratified with it. It was originally covered with a bed of guano. Prof. Hitchcock expressed the opinion that it was of igneous origin, which was contested by Mr. N. H. Winchell, who regarded a guano origin as most probable. Mr. E. W. Claypole presented a paper on "The Continents and the deep seas."

Prof. C. L. Herrick discussed "The Cuyahoga shale and the Waverly problem," distinguishing three horizons in the Waverly —the upper corresponding to the Keokuk and Burlington; the middle, to the Kinderhook; and a lower represented by the Berea. The Bedford shale was made Devonian.—N. H. Winchell presented a paper on the Taconic area of Minnesota and western New England, making out five horizons of iron ores in Minnesota —namely, in descending order, (1) The hematite and limonite of the Mesabi, represented by the Penokee-Gogebic Range, the ores originally iron-carbonate; (2) Titaniferous magnetite, associated with the great Gabbro range; (3) Siliceous magnetite, at the base of the gabbro; (4) The hematite and magnetite of the Kewatin, as at Vermilion Lake and Ely; and (5) The ores of the crystalline schists.

Prof. H. S. Williams discussed the question—What is the Carboniferous System? Mr. A. Winslow described the Geotechtonic and Physiographic geology of western Arkansas.

Mr. McGee read a paper by Lawrence C. Johnson on the Nita Crevasse on the Mississippi. It was stated that this crevasse was the most extensive that had been opened for many years. Through it an immense volume of water escaped into the lakes—a volume not yet accurately measured, but probably equal to that of the Missouri during flood, or that of the Delaware, Susquehanna, Potomac and James rivers. The effect of this vast volume of

fresh water was to transform the previously brackish lakes and saline bays into fresh-water lakes and estuaries. But the result, which it was the special purpose of the communication to bring out, was the destruction of the salt-water fauna and the substitution of fresh-water and mud-loving fauna over an immense area. During the recent year an important industry of the gulf coast about the outlets of the lakes mentioned was oyster fishing, but the oyster beds all along the coast have been injured and in many cases destroyed. The sea-fishery region has also been ruined, and the pickerel and other characteristic fishes of the Mississippi may now be taken where four months ago only salt-water forms were found. This transformation in the fauna of the region is of immense economic importance. Valuable industries have been destroyed; prices of standard commodities in New Orleans and other Southern cities have been affected. Of even greater scientific interest is the transformation, for it illustrates a transition from a marine to a fresh-water fauna over hundreds of square miles effected within a few weeks. Hitherto the geologist employed in the lower Mississippi region has been puzzled to account for sudden transitions from fresh-water to salt-water deposits, and vice versa; but there is here a modern example of as wide extent as in all those which have hitherto embarrassed the student.

The reading of geological papers was continued before the American Association then in session. A list of the papers is given beyond, on pages 339, 340.

2. *Making of Icebergs.*—Mr. Henry B. Loomis, of Seattle, was at the Muir glacier for nearly seven weeks this summer, with Prof. John Muir. In a description of the visit (which mentions the unfortunate feature of 20 days of almost continuous rain) he gives the following account of the making of icebergs at the terminal wall of the glacier.—Blocks of ice, some of them of enormous size, fall off from this wall at frequent intervals. The falling of the bergs is very irregular; at times a berg is discharged as often as every five minutes, at another time you may wait an hour without seeing one fall. On one day, during twelve hours, we counted 129 thundering reports, loud enough to be heard at camp, a mile or more from the falling bergs. During some days and nights, especially during a heavy rain, we were reminded of a cannonade or thunder-storm, and the ground beneath us seemed to tremble. Sometimes a huge block breaks off, crumbles into a million fragments, and, leaping like a catract, falls gracefully into the bay with a long thundering noise, scattering around the white and mealy spray which glistens in the sunlight, and making the water below boil with foam. Another enormous block is discharged, and, without breaking, sinks in an upright position into the water, causing a low, thundering noise; then it rises again, sometimes 250 feet, even with the top of the wall of the glacier, while the water rolls off its top like a cascade; then the berg topples over gracefully on its side and plunges into the water with a heavy, thundering roar, like the sound of artillery or of thunder, and the

spray is shot in every direction, falling like a myriad of comets or descending rockets—the spray itself often rises as high as the top of the terminal wall; and frequently we have seen such an iceberg, after falling, wallow about in the water among the other icebergs like a huge monster. Now and then a bowlder falls with a thud. When a large iceberg falls, a series of large waves, like rings, spread themselves around the center of disturbance, and soon gracefully roll or leap, in spiral form, upon the beach close to our camp—a mile away; and when the inlet is filled with floating icebergs there is great commotion.

3. *On Sandstone dikes in California;* by J. S. Diller. Bull. Geol. Soc. of America, i, 411, 1890.—Mr. Diller describes in this paper a number of dikes, resembling closely ordinary trap-dikes, but consisting of sandstone, made chiefly of granitic material, intersecting sandstones and shales of the Cretaceous group, on the northeastern portion of the Sacramento valley. They have a general parallelism, but vary in strike from N. 20° E. in the southwestern part of the region in which they occur to N. 70° E. in the northwestern. They are from a mile to less perhaps than a hundred yards in length, and occupy joint-fissures in the rocks. Very beautiful engraved plates illustrate finely the forms and positions of the dikes. The author discusses their origin at length and attributes the fractures to earthquakes, and gives reason for believing that they were filled from below. He observes that if we regard these dikes as earthquake phenomena their gentle curvature may indicate their relation to the center of disturbance far to the southeastward in the Sacramento Valley.

4. *Annual Report of the Director of the U. S. Geological Survey for* 1886–87, vol. viii in two parts, 1060 pp. with maps and other illustrations.—Of the Memoirs that make the body of this very valuable Report those of I. C. Russell, Lester F. Ward and G. F. Becker have been already noticed in this Journal. The others are on the Lassen Peak District, by J. S. Diller; The Fossil Butterflies of Florissant, by S. H. Scudder; The Trenton Limestone as a source of Petroleum and Inflammable Gas in Ohio and Indiana, by Edward Orton; The Geology of Mount Desert Island, Maine, by N. S. Shaler. The Report contains 76 plates besides a large number of figures in the text.

5. *Hawaiian volcanoes.*—(1) *Notes from* Wm. T. Brigham, in a letter dated Honolulu, August 26th, 1890.—I have just returned from Puna, Kilauea, Mauna Loa and Mauna Kea. The latter mountain has been covered with snow on the upper region to a greater extent this summer than for many years: hence we found the tarn Waiu at the summit platform, or at the base of the terminal cinder cones, quite full; indeed two springs were flowing in on the northeast corner, while a brook of some volume flowed out on the western side. The principal cone was bare externally, except at the very base, but its crater was nearly filled with snow. At Mokuaweoweo the steam and sulphur fumes are abundant in many places. The vapor has been frequently visible

from the shore. At Kilauea I found Dana Lake had decreased since last March about one-third, but was active, while fire has appeared to the south but still in the area of depression. Several sharp earthquakes have occurred at Hilo, and one of several distinct shocks was felt by me in northern Hawaii, at Waimea, as a long continuous rumble: at Laupahoehoe on the eastern shore the shocks were more distinct than at Kau in the southern part of the island. The time of transmission from Hilo to Laupahoehoe, four miles north, was estimated by telephone at 5″.

(2) *Notes from* ERNEST E. LYMAN, *on an ascent to the summit of Mt. Loa*, in a letter dated Hilo, August 20.—Since Mr. Lyman's former visit to the summit crater in 1888, part of the eastern wall, near "Pendulum Peak," twenty-five yards wide and over a hundred long, had settled thirty feet or more. His descent to the bottom of the crater, on August 7th (Thursday) was here made—the distance down by estimate about four hundred feet. Steam was rising over the bottom from a number of spots not far from the base of the western wall, through the length of the crater, but the amount had diminished greatly since 1888. No other marked changes were observed. Having made his descent to Kau, he learned that on Wednesday night a dozen earthquakes had been felt there, and more severely at Hilo and in Puna, where stone walls were thrown down. At Kilauea three were felt and changes took place in Halemaumau. On the summit, nothing of the earthquake was felt by him, but his guide reported in the morning his hearing "a groaning in the ground."

Mr. Lyman collected specimens from the layers of lava constituting the walls of the summit crater, which, after being studied, will be reported upon by Professor E. S. Dana, with further citations from his letter.

6. *Brief notices of some recently described minerals.*—NEOTESITE.—A hydrous silicate of manganese and magnesium occurring with tephroite at the manganese mines in Grythyttan parish, Oerebro, Sweden. It is massive, cleavable and resembles red orthoclase. Hardness=5–5·5. An analysis gave:

SiO_2	MnO	Mg	FeO	H_2O
29·50	40·60	20·05	*tr.*	9·85=100

The general formula is $R_2SiO_4+H_2O$, or a hydrated tephroite. —L. J. Igelström in *Jahrb. Min.*, i, 257, 1890.

CIPLYTE.—A supposed silico-phosphate of calcium occurring in the chalk at Ciply, and elsewhere in Belgium, associated with phosphorite. It has not been fully described.—J. Ortlier, ref. in *Bull. Soc. Min.*, xiii, 160, 1890.

PHOLIDOLITE (Folidolit).—A mineral allied to the chlorites, from Taberg in Wermland, Sweden. Occurs in small tabular twinned crystals of a grayish yellow color and pearly luster. Specific gravity 2·408. An analysis gave:

SiO_2	Al_2O_3	MgO	FeO	MnO	K_2O	H_2O
49·78	6·31	27·94	4·08	0·12	5·93	5·49=99·65.

The formula deduced is K_2O, $12(Fe, Mg)O$, Al_2O_3 $13SiO_3+5H_2O$. —G. Nordenskiöld in *Geol. För. Förh.*, xii, 348, 1890.

KALIBORITE.—A hydrous borate of magnesium and potassium occurring with pinnoite, which it closely resembles, near Aschersleben, Prussia. It is massive with granular structure, and specific gravity=2·05. An analysis gave:

B_2O_3 57·46 MgO 12·06 K_2O 6·48 H_2O 24·00=100

—W. Feit in *Chem. Zeitung*, 1888, 1889.

PHOSPHOSIDERITE.—A hydrous ferric phosphate described by W. Bruhns and K. Busz as occurring at the Kalterborn mine near Eiserfeld. It is orthorhombic and appears in prismatic crystals, tabular parallel to the brachy-pinacoid. Hardness=3·75, specific gravity=2·76. Color peach-blosson red or reddish violet. An analysis gave:

P_2O_5 38·85 Fe_2O_3 44·30 H_2O 17·26=100·41

This corresponds to $4(FePO_4)+7H_2O$, which brings it very near strengite, to which it is also allied in form, though the two minerals appear to be distinct.—*Zeitschr. Kryst.*, xvii, 555.

SIGTERITE.—Described by Rammelsberg as a new member of the feldspar group. It occurs associated with the eudialyte and albite of Sigterö, Norway. Structure granular; color gray; cleavage like that of orthoclase, with polysynthetic twinning. Extinction on (001) inclined $\pm 3\frac{1}{2}°$ to $4\frac{1}{2}°$, and on (010) $+16°$ to their intersection-edge. Specific gravity 2·600—2·6222. An analysis gave:

SiO_2 50·16, Al_2O_3 28·64, Na_2O 13·63, K_2O 3·96, FeO 1·97, CaO 0·98, MgO 0·16 ign. 0·42 = 99·92.

Deducting a little admixed augite, this becomes

SiO_2 50·54, Al_2O_3, 30·64, Na_2O 14·58, K_2O 4·24 = 100,

which gives the formula $(Na_1K)_2Al_2Si_3O_{10}$, or that of an anhydrous natrolite.—*Jahrb. Min.*, ii, 71, 1890.

ÅKERMANITE.—A lime-magnesia silicate, containing no alumina, and belonging to the tetragonal system like melilite, with which it is closely related. It is not known in nature but has been obtained by Vogt in connection with an important series of experiments upon the formation of minerals from fusion. —*Arch. Math. Nat. Kristiania*, xiii, 311, 1890.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *American Association for the Advancement of Science.*—The thirty-ninth meeting of the Association opened at Indianapolis on Tuesday, August 19th, nineteen years after the previous meeting at this place, Professor George L. Goodale, of Cambridge, President. The address of the retiring president, Prof. Mendenhall, discussed in a forcible way some of the relations of science to the general public.

Washington was selected as the place of meeting in August, 1891. The officers elected were as follows: *President*, ALBERT B. PRESCOTT of Ann Arbor. *Vice-presidents* of the Sections, E. W. HYDE, Mathematics and Astronomy; F. E. NIPHER, Physics; R. C. KEDZIE, Chemistry; THOMAS GREY, Mechanical Science and Engineering; J. J. STEVENSON, Geography and Geology; J. M. COULTER, Biology; J. JASTROW, Anthropology; S. DANA HORTON, Economic Science and Statistics.

The American Committee of the International Congress of Geologists, appointed by the American Association, as explained on page 166 of this volume, was discharged.

Sections A, Mathematics and Astronomy, and B, Physics.

E. H. MOORE: The Problem, to circumscribe about a conic a triangle which shall be inscribed in a triangle which is itself inscribed in the conic, and a certain question concerning two binary cubics.

J. D. WARNER: A method of testing for primes.

J. A. BRASHEAR: Recent photographs of the moon by direct enlargement. The great Lick Spectroscope. Recent studies in the ultra-violet spectrum. A new self-regulating photometer.

FRANK H. BIGELOW: Further study of the solar corona. Terrestrial magnetism.

C. H. ROCKWELL: Some personal experiences on the expedition to Cayenne, French Guinea, to observe the eclipse of 22d Dec., 1889.

CLEVELAND ABBE: Some results of observations made during the recent U. S. expedition to the west coast of Africa. Aberration methods of determining the altitudes and motions of the clouds. The marine nephoscope.

E. D. PRESTON: Magnetic and gravity observations on the west coast of Africa and at some islands in the Atlantic.

R. S. WOODWARD: The effects of the atmosphere and oceans on the secular cooling of the earth.

THOMAS GRAY: Earthquake and volcanic action in Japan. A new transmission dynanometer. Exhibition of seismograph.

T. C. MENDENHALL: Use of the magnetograph as a seismoscope. New metric standards.

T. RUSSELL: Prediction of cold waves from Signal Service weather maps.

F. E. NIPHER: Surface integrals in meteorology. Method of measuring the electrical resistance of liquids.

J. TROWBRIDGE and W. C. SABINE: Electrical oscillations in air.

A. E. DOLBEAR: On maximum temperatures.

E. W. MORLEY: Determination of the tension of the vapor of mercury at ordinary temperatures.

O. T. SHERMAN: Exhibition of Verns' photographs in natural colors.

E. W. MORLEY and H. T. EDDY: Report on the velocity of light in a magnetic field.

WM. A. ROGERS: Description of the equal-temperature room in the observatory and physical laboratory of Colby University. Is thermometry an exact science? Exhibition of a combined meter with subdivisions to 2mm. and a yard subdivided to tenths of inches, both being standards at 62 deg. Experimental determination of the time required for water to pass from 42° to 72° in a constant air temperature. Evaporation as a distributing agent in a determination of the temperature of water. Experimental determination of the rate of change in underground temperatures at a depth of nine feet by means of a flow of water at a constant level.

E. L. NICHOLS and B. W. SNOW: Radiation at a red heat; preliminary note on the radiation from zinc oxide.

ELI W. BLAKE: Exhibition of plans and sketch of the new physical laboratory, "Wilson Hall," of Brown University, Providence, R. I.

H. S. RODGERS and THOMAS FRENCH, Jr.: On certain electric phenomena in Geissler tubes.

W. F. DURAND: Magnetic and electric phenomena viewed as manifestations of strain.

E. B. ROSA: The specific inductive capacity of electrolytes.

G. W. HOUGH: Discussion of the formulas indicating the work of an electric motor.

A. L. AREY: Plan for a resistance box.

J. E. DENTON: On the specific heat of brine near 0° Fahr.

W. H. HAMMON: Observations taken in four balloon ascents.

D. P. TODD: On a form of pneumatic commutator and its use in the automatic operation of physical apparatus.

F. W. VERY: On the phosphoric lamp.

P. H. VAN DER WEYDE: On the advisability of applying the C. G. S. system of modern electricians to the principles of elementary mechanics.

D. T. SMITH: Flow and friction of fluids in open channels—theory of streams.

THOS. FRENCH, Jr.: Actinic action of electrical discharge.

MORRIS LOEB: Is chemical action influenced by magnetism?

A. TUCKERMAN: Index to the literature of thermodynamics.

C. A. OLIVER: Description of a series of tests for the detection and determination of sub-normal color-perception, designed for use in railroad service.

WELLINGTON ADAMS: Ampere-meter for feeble alternating currents: the Farado-meter.

ERNEST MERRITT: Note on certain peculiarities in the behavior of a galvanometer when used with a thermopile.

Section C. Chemistry.

H. W. WILEY: Knorr's extraction apparatus. Some new forms of apparatus for drying substances in an atmosphere of hydrogen. Apparatus for recovering highly volatile solvents. Pine tree sugar (*Pinus Lambertiana*). Pine tree honey dew and pine tree honey.

H. W. WILEY and H. E. L. HORTON: On the alkaloidal principles present in the seed berries of *Calycanthus glaucus*.

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E. H. S. BAILEY: On the minerals constituting a meteorite found in Kiowa county, Kansas.

J. U. NEF: Constitution of Benzoquinone.

P. C. FREER: The action of sodium on acetone and the constitution of aliphatic ketones.

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C. C. ABBOTT: Exhibition of a bone image from Livingston county, N. Y. Exhibition of gold beads of Indian manufacture from Florida and New Jersey.

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Section I. Economic Science and Statistics.

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LAURA OSBORN TALBOT: Natural resources of Loudon county, Va. Economic value of the energy of neglected children.

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WM. H. HALE: Ethics of strikes.
GEO. W. HOLLEY: Floods of the Mississippi and how to prevent them.

2. *British Association at Leeds.*—The meeting at Leeds commenced its sessions on the 3d of September. The inaugural address of the President, Sir Frederick Augustus Abel, treated of the practical achievements of physical science during the past 32 years—the interval since a former meeting at Leeds.

The address of the President of the Association and those of the Vice-Presidents, together with full reports of the papers presented at the meeting, will be found in the successive numbers of Nature, commencing with that for September 4. This excellent weekly Journal of Science should be in the hands of all interested in science and its progress. Its semi-annual volumes begin on May 1 and Nov. 1.

3. *An American Geological Railway Guide*, giving the geological formation at every railway station, with altitudes above mean tide-water, notes on interesting places on the routes, and a description of each of the formations; by JAMES MACFARLANE. Second edition, revised and enlarged, edited by James R. Macfarlane. 426 pp. New York, 1890 (D. Appleton & Co.).—This new edition of Dr. Macfarlane's excellent hand-book for geologists and tourists, on which he was working before his death in 1885, has been edited by his son with much care, producing a valuable thesaurus and compendium of information concerning the geology, the mineral deposits, and the best localities for collecting fossils and examining geological sections in Canada, the United States and Mexico. The scope of the book is well seen from the title page, as above quoted. Its reliability is guaranteed by the names of the geologists of the several State, United States, and Canadian geological surveys, who have supplied full notes of their respective fields of investigation. W. U.

4. *Royal Society of N. S. Wales.*—Vol. xxiii, Part 2, of the Journal and Proceedings contain, covering 160 pages, a list of the marine and freshwater Invertebrate fauna of Port Jackson and the neighborhood, by I. Whitelegge; on the occurrence of platinum in a feldspathic vein in the Broken Hill district; on the Australian Aborigines, and other papers.

5. *Smithsonian Miscellaneous Collections*, no. 741: Index to the Literature of Thermodynamics, by A. Tuckerman. 240 pp. 8vo. 1890.

6. *Verzeichniss der Schriften über Zoologie von Dr. O. Taschenberg, of Halle.*—The eighth "Lieferung," signatures 281–320, of this important zoological bibliography has been issued by W. Engelmann. It finishes the Hymenoptera and commences the Coleoptera.

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